STRATEGY
OF FIREFIGHTING

Vincent Dunn, Deputy Chief, FDNY (Ret.)

Fire Engineering®

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PennWell Corporation
1421 South Sheridan Road
Tulsa, Oklahoma 74112-6600 USA

800.752.9764
+1.918.831.9421
sales@pennwell.com
www.pennwellbooks.com
www.pennwell.com

Director: Mary McGee
Managing Editor: Marla Patterson
Production/Operations Manager: Traci Huntsman
Production Editor: Tony Quinn
Book Designer: Susan E. Ormston Thompson
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To those who wonder what a fire ground commander thinks.

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PREFACE

This book is intended for anyone who practices firefighting strategy. At the core are firefighting strategies for the most common types of fire scenarios: private dwellings, strip malls, row houses, places of worship, restaurant kitchens, truss constructions, stairways and hallways, cellars, apartment buildings, high-rise residences and offices, heavy timber factories, noncombustible buildings such as warehouses, vacant buildings, grass and brush fires, and terrorist explosions. Also identified are specific firefighting problems that each occupancy and construction type presents to an incident commander. Even more important, firefighting solutions are given.

Recommendations for stretching the first and second hose lines, portable ladder positioning, primary venting, aerial ladder placement, primary life hazard areas, interior and exterior fire spread, recurring situations, collapse dangers, and safety precautions are given for the aforementioned fire scenarios. In addition, worst-case scenarios, experienced during my career as a chief officer, are given as lessons in what not to do. This is a how-to book by a know-how person.

Included in this book are firefighting plans, standard operating procedures, action plans, ideas, guidelines, explanations, key steps, and systems of firefighting procedures. The fire service has plenty of firefighting strategies. Some are good, and some are not; the difference is explained. The strategies put forth in this book have been used and validated during my experience over a quarter of a century.

This book is based on primary research, rather than strategies gleaned from other books in a library. It comes from years of firefighting experience and contains insights, observations, inquiries, critical analysis, a few experiments, and plenty of trial and error. There is an entire chapter about firefighting errors and failures.

The role of teams in strategy is emphasized throughout the book. The incident commander does not make a fire go out; rather, successful firefighting needs a team. Firefighters, company officers, and sector officers are that team. Once a strategy is decided on, it requires the team to achieve the goal of fire extinguishment. I am blessed to have worked with some of the finest teams in the Fire Department of New York.

When I write about a fire operation mishap, I do not blame the firefighters. I blame myself, as the incident commander, and my strategy. When something goes wrong, I know I am responsible and seek to remedy the problem. After a failure, there should be a plan and a success.

The safety of firefighters is never far from my mind. Strategy is examined through a prism of safety. Firefighter safety is part of every strategy. Whatever the strategy, this message rings clear: Think firefighter safety! Learn—and stay alive! This book is big on information and lessons learned, not on bluster and boasting.

What is a strategy? It's a plan of firefighting. This book is not about tactics, nor is it about details. It is about strategy and about logical ways to solve a life hazard or fire spread problem at a fire, big or small. Strategy in this book explains a proposed sequence of action. Strategy is an outline, a design, an action plan, and a solution.

One of my main reasons for writing this book was to pass on information to future fire service leaders. Every fire officer has a responsibility to pass on the lessons learned to the next generation of firefighters. I call these strategy summaries, but they are actually the lessons that I have learned, and I am passing them on to the 21st century fire officers.

The Strategy of Firefighting was written because future incident commanders may lack the firefighting experience of fire chiefs who lived through this nation's urban firestorms in the last half of the 20th century. Firefighting is just one of the many responsibilities of an incident commander, because today the fire service does more than fight fires. In the 21st century, chiefs must have much more knowledge and a wider set of skills and experiences. The one skill that we developed was firefighting strategy, and it must not be forgotten.

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1 STRATEGY FOR THE 21ST CENTURY

Firefighting strategy began to be documented in the last half of the 20th century. Firefighting strategy as we know it today did not yet exist. In the 1930s and '40s, there were no chiefs' development courses at the national fire academy and no textbooks with which to study firefighting strategy.

Back then, when a chief responded to a fire, no feedback information about the firefighting procedures could be used, because there were no radios on the fire apparatus. The chiefs who responded to fires then simply were out of service for the duration of the fire. There was only silence: no radio reports describing the smoke and flames coming out of windows; no shouts over a radio of a daring rescue taking place; no progress reports of firefighters injured by smoke explosions, flashover, or building collapse. The chiefs were simply gone—out of the firehouse for hours, supervising the fire attack—and nobody other than those at the fire really had any idea what was going on. Only the dispatch bells in the firehouse gave some hint of the progress of the fire—or the lack thereof. When they sounded,

two—two—Box—eight—four—five
[second-alarm fire]

then,

three—three—Box—eight—four—five
[third-alarm fire]

and then again,

four—four—Box—eight—four—five
[fourth-alarm fire]

it was not good.

During a fire, there were no orders for such things as a command post, a staging area, progress reports, sectoring, an incident command system, fire ground communications, exposure size-up, an under-control signal, and postfire analysis. When the chief returned to quarters after the fire, he tapped on the firehouse telegraph system, relaying that he was back in service and available for another fire. He then went upstairs to his office. Only the senior fire officer might dare ask him a question about the fire. Only the chief knew what had happened.

Not until the 1950s did we begin to learn about a fire chief strategy at a fire. Firefighting strategy started to be compiled in the 1950s and was expanded thereafter. In the 1960s and '70s, the fire service discovered firefighting strategy. In the 1980s, we discovered fire ground management, and in the 1990s, risk management became a study of the fire service. In the 21st century, the fire service is once again taking a close look at its firefighting strategy. Strategy is how we plan to use firefighters, apparatus, and equipment at fires and emergencies.

Command Post Strategy

A fire department should have a strategy for how, when, and where to set up a command post. A command post should be set up at every fire. The fire operation is directed from this location. A command board is set up to record where units are operating (fig. 1–1). Incoming companies report there for assignments. After the fire is extinguished and companies are released, they report to the command post before leaving the scene. The incident commander must be at this location. If the commander leaves for even a short period, his or her representative or aide must remain at this location to relay orders and receive communications.

At a fire in a low-rise building, the command post is normally set up at exposure A, the front of the building. At a high-rise fire, the command post can be in the lobby of the building or in the street. If the command post is in the lobby of a high-rise building, steel and concrete could prevent the radio transmissions from reaching the upper floors. If the command post at a high-rise fire is located in the lobby, to improve radio transmission, a radio relay team should be positioned outside the building at a safe location. Radio communications could be relayed from the lobby to the street to a cross-band repeater, from which the signal could then be relayed to the upper floors. In a central-city location, because of people and traffic congestion, the incident commander may have to announce over the department radio the exact location of the command post. This is necessary so that incoming units can find it amid the crowds and traffic.

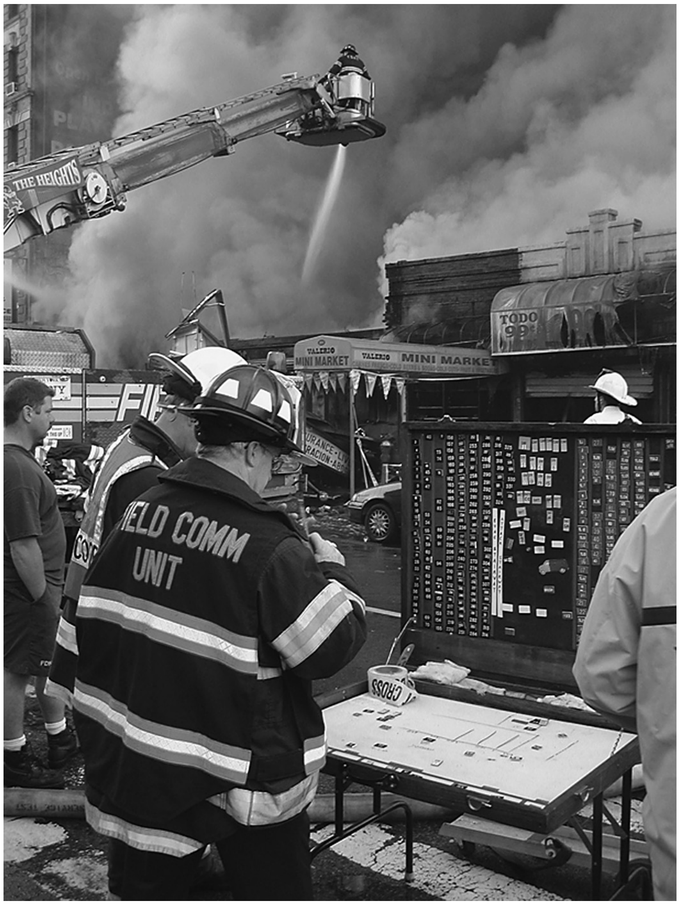


Fig. 1–1. Establishing a command post.

Staging Apparatus

A fire department should have a strategy for staging large numbers of fire apparatus responding to a fire. At a small fire, 5–10 fire vehicles may respond to the scene and have to park. These parked fire apparatus and special units create three problems, one of which is especially serious. First, fire apparatus left parked in the street while firefighters battle a blaze can create traffic gridlock.

Second, and more serious, these vehicles interfere with the quick repositioning of aerial ladders, rescue companies, and ambulances to the front of the burning building. Finally, and of utmost concern, apparatus positioned near a burning building may be in the collapse danger zone, and firefighters performing pumping operations or attempting to move apparatus could be buried during a building collapse.

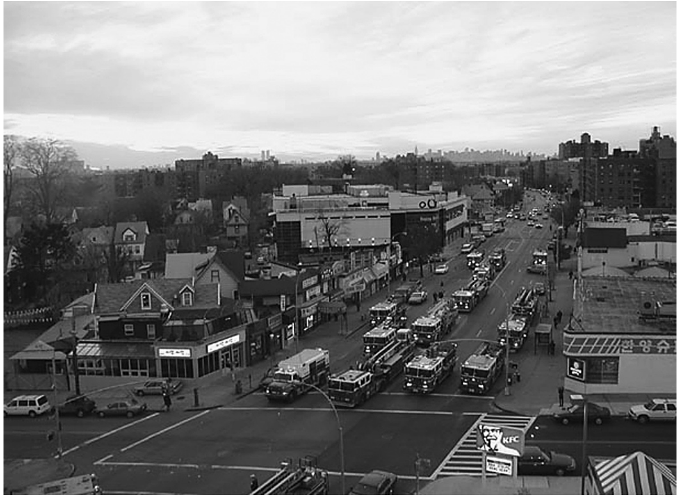


Fig. 1–2. Level II staging, designating the location for apparatus in the street.

At the early stages of a routine fire, only the chief car and the first-arriving engine and ladder should enter the street where the fire or emergency is taking place. This is called level I staging and should automatically be performed by first arriving units. All other responding apparatus should stay out of the street and park at the corner, ready for repositioning. This standard operating procedure should not have to be announced over the department radio.

When it appears a major incident (a major fire or emergency) will occur, the chief responding should designate a staging area location and a staging officer. If there is a known empty space or a parking lot nearby, this area can be designated the staging area by the chief. This is called level II staging and is critical during a large incident, as shown in figure 1–2.

An inner-city or downtown area presents challenges when designating a staging area. In New York City, during a major fire in a midtown location, on a one-way street, some fire ground commanders order the staging location at the nearest intersection. For example, if a fire or emergency happens on a one-way street going uptown, the staging should be designated at the first or second intersection on the uptown side of the fire. This is because on an uptown, one-way street, the police will stop traffic at the downtown side of the fire. The intersection uptown, on the other side of the fire, will be less congested. This is just the opposite when a one-way street has traffic going downtown. The staging location should be designated at an intersection downtown from the fire building. When a high-rise fire is in the middle of a block, the staging area can be at the intersection farthest from the fire building. This will separate staging from the operations at the fire. An officer or the chief's aide can be put in charge of the staging area until a chief can be specially called to the scene to take over staging.

Accounting for Firefighters at the Scene

A fire department should have a strategy to account for firefighters operating at a fire. An accountability strategy is designed to prevent a firefighter from becoming lost during a fire. It also reduces freelancing during a fire—freelancing being a term used to describe a firefighter wandering around without supervision during a fire. An accountability strategy tracks or accounts for the activities of firefighters. The accountability system helps control the movements of everyone operating at the incident.

Chiefs and company officers must understand, though, that accountability cannot be delegated to a system. Everyone is accountable and everyone at a fire has a responsibility to be accountable. For example, the incident commander ultimately is responsible for the entire fire operations area. However, realistically, the incident commander can track only the sector officers. The command chief cannot know the exact position of all 100 firefighters operating at the scene. In attempting to do so, he or she will lose control of the fire, and there will be no strategy. The incident commander is responsible for knowing where the sector chiefs under his or her command are operating. The sector chiefs are accountable for knowing where all the companies in their sector are operating. The most important part of accountability at a fire or emergency is the company officer. The captain or lieutenant must control the firefighters under his or her command. Finally, each firefighter is accountable to the officer of the company.

The incident commandeer needs everyone at the scene to assist in the accountability task. The best accountability system is when the incident commander and all sector chiefs, company officers, and firefighters are accountable for their area of responsibility. Fire ground accountability in addition to control of the fire ground creates fire ground safety. The incident commander cannot do it alone. The incident commander needs the sector chiefs and company officers and firefighters to be accountable for their actions.

A computerized tracking system is being developed by New York University as a result of the recommendation of the McKinsey & Company study of the 9/11 terrorist attack on the World Trade Center. An electronic command post board for the incident commander has built-in computer notepads that contain Global Positioning System (GPS) devices used by sector officers and company officers. This electronic command board may be available to assist the fire service during fires and emergencies.

Before the ceremony in which I was promoted to deputy chief along with several other candidates, the chief of department gave the group a pep talk. He told us that when he arrived at the scene of one of our fires and assumed command, he expected us to know the names and unit numbers of the battalion chiefs under our command at the fire. He stated that I should know the location of the sectors inside or around the fire building to which they were assigned and, further, that we should expect battalion chiefs to inform us of the identifying numbers of the companies and the locations where they had been assigned to operate by the battalion chief. Additionally, the chief of department stated that the command board should be set up and all of this information should be recorded on it by the time he arrived at the command post.

Locating a Fire

Before an incident commander can decide on a firefighting strategy, the fire must be located. Firefighters must determine on what floor the fire is burning. Is the fire in the cellar, the basement, the second floor, or the fifth floor? Firefighters must know the exact floor of the fire in order to safely use the elevator, estimate hose lengths to stretch, to establish priorities of search and rescue, and to predict where the fire will spread vertically.

Most of the time, on arrival at a house fire, the fire floor is easy to determine. We see the smoke or flames at a window and we count the stories. However, when the fire is at the rear of the building, or when thermal double-paned windows conceal the smoke and flame, or at night, or in a high-rise building, determining the fire floor requires that a firefighter enter the building and search for the flame and smoke. After discovering the flame, the firefighter must look for the floor number sign, usually posted in the stair enclosure, and communicate the floor on fire to the incident commander downstairs, at the command post.

Every once in a while, the exact floor on fire is not accurately determined during the initial size-up, and firefighting strategy and tactics are ineffective. There are several reasons why the fire floor might be misidentified. First, sometimes the floor number signs in the stairways are incorrectly labeled. The first floor is incorrectly labeled the ground floor and the second floor is labeled the first floor and so on; the lowest level of an aboveground multistory building is the first floor, not the ground floor. Also, at some row houses, you have to step down several feet below street level to a doorway located beneath a stoop; this level is considered a basement, and it is supposed to be designated the first floor by firefighters. A basement has over one-half of its floor level above street level and is considered the first floor; a cellar, by contrast, has one-half or more of its floor level below ground and is not considered the first floor. A row house building with a cellar, basement, and two levels above is considered a three-story building during a firefighting size-up.

Finally, some high-rise buildings omit the number 13 when designating floor numbers, because people who believe 13 is an unlucky number would not want to live or work on that floor. Many hotels and office building have no number 13 on the elevator call buttons. Whenever a firefighter discovers the floor signs mislabeled, or the presence of a basement, or the absence of the 13th floor number on the elevator call buttons, that information should be immediately relayed to the chief in charge of the incident.

Size-up Strategy—Inside and Outside a Burning Building

A fire department should have a strategy for conducting a size-up at a fire. The first-arriving incident commander at a structure fire should establish a command post in front of the fire building and size up the fire from the outside. When a second commander arrives, this officer is designated an operations officer and is sent into the building, to establish an operations post and size up the fire from the interior, close to the action.

Size-up of an incident should be accomplished both from the inside and from the outside of a burning building. For example, the operations officer is in charge of the initial hose line and serves as the interior search operations officer; he or she makes an inside size-up. The incident commander outside the burning building at the command post is in charge of the entire operation and will conduct an outside size-up. At most fires, the incident commander will request a size-up from the operations officer, then make an analysis of the fire outside, and transmit a radio size-up report of the operation to the dispatcher.

At the initial stage of a fire when flames are confined to one floor, the inside size-up is more accurate and useful than the size-up made from outside the burning building. The operations officer inside the structure is closer to the fire and obviously can see more of it than someone standing outside. However, when a fire spreads through the roof, or involves two or more floors, the outside size-up becomes more accurate. The fire officer inside the building can see only the fire on one floor. The operations officer inside cannot see the amount of fire above, in the roof, or on the floor(s) above. Given the limited view inside, the operations officer may believe that the fire involves only one or two rooms on the burning floor and that the blaze can be extinguished quickly, when the entire roof or several floor above may actually be involved in fire above. At the World Trade Center fire, after the planes crashed into the towers, firefighting inside the towers suffered from a limited view of the incident. Fire chiefs responding from across bridges to the burning 110-story towers had a better understanding of the fire and destruction to the burning buildings. Two size-ups—one inside and one outside—should be the strategy during every fire and emergency.

Identifying the Direction of Fire Spread

Wind direction is one critical factor that an incident commander must analyze to cut off fire extension and extinguish a fire. Furthermore, wind direction is the most important weather factor to consider during the initial size-up. The incident commander must know the wind direction to plan an effective fire strategy and make correct decisions.

For example, the chief in charge of a strip mall fire must immediately determine the direction of fire spread in order to correctly determine where to order the positioning of his second hose line to prevent fire extension. On arrival at a fire, the incident commander looks at the fire to determine the direction in which smoke swirling around the burning store is moving. The direction of smoke spread tells the chief the direction the wind is blowing, and the direction of the wind tells the chief the direction of fire spread that is taking place in the common roof space over the stores. This may seem obvious, but it is an important part of the chief's fire size-up, and it is accomplished subconsciously, sometimes without realization of the important role that wind direction plays in a size-up.

Wind speed is also an important factor during a fire. High winds cause conflagrations. Any veteran knows that you cannot fight a fire against a forceful wind and that you cannot advance an attack hose line against the wind; high winds coming from an open window, blowing flames down an apartment hallway into the face of the attack hose team, will stop the advance. Also, winds gusting over 30 miles per hour can turn small building or brush fires into raging conflagrations. Even large-caliber master streams will not stop a wind-driven fire.

Standard Operating Procedures

A standard operating procedure is a strategy for having arriving fire companies perform a specific task at a specific location. A strategy that incorporates standard operating procedures provides accountability and control. It is a general first responder's plan of who does what and where.

Standard operating procedures let companies know where they should be operating and what they should be doing when first arriving at a fire before the chief gets there. For example, a standard operating procedure for working a fire at a multistory dwelling may involve two companies. Even if the chief has not yet arrived, the standard operating procedure allows the officers of the first- and second-arriving companies to stretch the first attack hose line and search for victims on arrival. The standard operating procedure may be very simple:

The firefighters with the first-arriving company stretch the hose to the fire; and the second-arriving company performs vent and search-and-rescue operations.

A standard operating procedure is a strategy for fire companies.

Incident Management

The incident command system, now called the National Incident Management System (NIMS) by the fire service, represents a strategy for command. The five management or command functions are command, operations, planning, logistics, and finance. The incident commander may decide to perform all command functions at an incident or may delegate some or all of them to incoming officers.

If one command function can be said to be delegated most often, it is operations. An operations officer is most often designated by the incident commander at fires and emergencies. The operations officer sets up an operations post close to the incident, for size-up. Next most common is the designation of a logistics officer. Staging of apparatus is the most frequently encountered logistics problem requiring management at a fire or emergency scene. A planning officer may be assigned when things get hectic at a large operation. The incident commander designates a planning officer in order to focus on the immediate command decision making; by contrast, the planning officer can think over the long term. Finally, when mutual aid and/or specialized outside services are called to assist at an operation, a finance officer may be designated to estimate, document, and record the time and equipment use and costs to the local government.

Fire Ground Communications

This is the least understood strategy in the fire service. There is great misunderstanding about communications flow in the fire service. Who notifies whom of a dangerous condition during a fire or emergency is not clear. Company officers and firefighters must realize they are responsible for notifying the incident commander of hazards discovered. Unfortunately, many firefighters erroneously believe that the warning to get off a roof or to back out of a cellar will come from the chief, who is standing outside, at the command post. This is a deadly misunderstanding that has cost lives in the past. The truth is, the fire chief cannot see fire conditions inside the building from the command post. He or she cannot see the crack of the rear wall. Nor can the chief evaluate the stability of the roof or the floor inside a burning building. Actually, the chief is depending on the sector officers and the company officers and the firefighters close to the operation to tell him or her of these dangerous conditions. The sector officers, company officers, and firefighters are the eyes and ears of the incident commander. Nevertheless, it becomes the responsibility of the incident commander, once notified of a danger, to take any action necessary to protect all the officers and firefighters across the entire operation.

After many tragedies, firefighters come forward and tell of seeing warning signs before the event; however, they did not report these to the incident commander, and lives were lost. Only an incident commander who receives and acts on radio reports of dangers can ensure safe operations. Some chiefs do not want to hear bad news, and they discourage warnings from officers and firefighters or do not respond to messages of reported dangers. However, without open communication channels, an incident commander may lack a complete picture of the fire operation.

Fire Ground Designation

A fire department must have a strategy for defining the fire ground around a burning building. The fire ground area must be defined, and everyone must know the defined area. Exposure A is the area in front of the fire building. The command post is usually located within exposure A. Proceeding clockwise from the command post, exposure B is the left side, exposure C is the rear, and exposure D is the right side of the burning building. When you give orders from the command post or receive orders from fire officers working around the building, you must use this or another fire ground designation system that identifies the four sides of a burning building.

It can be deadly if firefighters do not know where they are operating around the outside of a burning building. Also, if the incident commander cannot pinpoint the exact side of a burning building where a hose line should be stretched or where to search for a victim trapped at a window, there can be no strategy at a fire. If no fire ground designation system is used, then everyone can be considered to be freelancing.

Fire Building Designation

A fire department should also have a strategy for defining the area inside a burning building. When fighting a fire in a house fire, if you know what floor you are on and what floor the fire is burning on, then there is usually no need to further break down the interior floor area into smaller parts or sections. However, if you are working a fire in a large apartment building or a building containing a row of several stores where flame is spreading in the roof space, or if you are searching in a large-area high-rise building with many offices, to communicate effectively with the command post, you must use an interior building designation system. An interior building designation system allows you to subdivide the floor area into smaller parts and to pinpoint and communicate your exact location inside the burning building, as well as the precise location of a spreading fire discovered during a search inside a large-area building.

One of the most simple and commonly used interior building designation systems for large apartment house fires is to break up the apartment sections (wings) into letters *A*, *B*, and *C*, from left to right—starting with *A* at the left section (wing)—as viewed from the command post. Also, each section can be further subdivided, if necessary by designation of *front*, *middle*, and *rear*. The smaller intermediate portions connecting the sections (wings) of a large apartment house can also be designated; they can be a *core* section, or a *connecting* section, or a *throat* section.

A large building (e.g., a strip mall) containing many smaller stores is another structure where a building designation system is critical to pinpoint exactly where you are operating and/or exactly where the flames are spreading in the common roof space over the stores. A commonly used interior building designation used during a fire in a strip mall is a system of adding number to the sector letters B and D. For example, the row of stores located on the left side (as viewed from the command post) of the store where the fire started will be designated exposures B, B1, B2, B3, and so forth; on the right side of stores will be exposures D, D1, D2, D3, and so forth. Similarly, store B is the one immediately adjacent to the original burning store, and moving away from the fire, you have stores B1, B2, B3, and so forth; stores on the exposure D side of the fire (the right side as viewed from the command post) would be designated D, D1, D2, D3, and so forth, proceeding away from the original fire store. An important point to consider at a fire in a large strip mall is that even though there are several stores in the complex or row, each with a different address, they may all be located in one building or structure. You could have a fire involving several stores in one single, large structure. Check the party walls on the roof to identify the exact area of the building.

Finally, in a distribution center or large-area office burning building, the entire floor area can be divided into two halves. When viewed from the front of the fire building, the left side is the A section (half), and the right side is the B section (half). The center area, containing the stairs elevators and utilities, can be further designated as the core area, if necessary, to pinpoint a fire's exact location in a large-area high-rise building.

Progress Reports

There must be a strategy for reporting the progress or lack of progress of a fire operation. In today's information age, the incident commander cannot simply go out of service during a fire and not inform the upper command of the fire, as in the past. On arrival at the scene, the incident commander must announce arrival. Then, the first progress report, called the preliminary report, requires the incident commander to give a radio report of the fire description, the fire building, the surrounding property, and the fire spread. For example, this report might say,

> *We have a fire in a 2½-story, wood frame building, 25 feet by 50 feet; fire is located on the second floor and possibly the attic. The exposure threat is the B side. An attack hose line by engine 1 is being stretched.*

The subsequent progress reports are given over the radio to the dispatcher by the incident commander. These progress reports describe in detail the strategy that will be used (interior offensive attack or outside defensive attack). These reports also include requests for additional companies to respond when needed and announce the results of the primary and secondary searches. The final progress report announces that the fire is declared under control.

Preliminary and subsequent progress reports over the department radio are very important. They provide a description to chiefs and companies of the kind of fire or emergency to which they are responding. Furthermore, they allow the fire chief to monitor the incident from headquarters. Most important, progress reports make the incident commander at the scene constantly reevaluate and assess the results of this strategy. Radio progress reports are a fire ground commander's internal system of checks and balances.

Search Strategies

A fire department must have a strategy for searching a burning building for victims. The strategy used to locate victims during a fire is to conduct two searches. Firefighters first make a quick primary search to look for unconscious victims with the advance of their attack hose line. The secondary search is more methodical, a slow and careful search of the entire fire building and the area around the burned-out building for victims. The secondary search is usually performed after the fire is controlled. One of the most important radio reports given by the incident commander is the results of primary and secondary searches. The incident commander must request that companies operating inside the burning building conduct a primary search of the fire area and a secondary search of the entire building and its surroundings. Nothing indicates a poor firefighting operation more clearly than the fire department's leaving the scene of a fire and a victim's being found in the rubble several days later.

Hazardous Material Incident Danger Zones

In the 21st century, all fire departments must have a strategy for hazardous material incidents. During a terrorist chemical attack or hazardous material incident, an incident commander must immediately establish *hazard work zones*. The three hazard work zones are the *hot zone* (exclusion zone), the *warm zone* (contamination reduction zone), and the *cold zone* (the hazard-free zone or noncontaminated zone). These hazard work zones are created to limit contamination of the public and firefighters. All emergency personnel must know what the different hazard work zones mean, and they must know which hazard zone to enter and which hazard zone to avoid. Movement between these on-scene hazard work zones is controlled at guarded checkpoints. Wooden barricades, barrier tape, or rope must be used to define the hazard work zones.

The hot zone (contaminated area)

Firefighters should never enter the hot zone once it has been defined, unless wearing special protective HAZMAT clothing, and if this does happen by mistake, the firefighter must retreat to the warm zone (decontamination zone) through a checkpoint and be decontaminated. Only firefighters equipped with special chemical or HAZMAT protective equipment should enter the hot zone or the warm zone; all other firefighters should remain in the cold zone. The hot zone (exclusion zone) must be avoided by firefighters wearing normal protective clothing, such as turnout gear, masks, hood, and helmet.

The warm zone (decontamination area)

This area is located between the hot zone and the cold zone (noncontaminated zone). The warm zone should be located at the scene, upwind and uphill from the hot zone. It is established to provide an area where on-scene decontamination takes place. Decontamination procedures are conducted only in the warm zone. Contaminated civilians and emergency personnel and equipment are cleaned and decontaminated in the warm zone. Decontamination procedures, such as clothing removal, showering, and monitoring, are carried out in the warm zone.

The cold zone (noncontaminated area)

The cold zone is a hazard-free zone where the command post staging area and sector commands are established. Firefighters responding to a hazardous material incident or terrorist incident report to the command post.

Explosion Withdrawal Distance

In the 21st century, all fire departments must have a strategy for operating at terrorist bomb threats and explosions. The National Fire Protection Association recommends that firefighters never attempt to fight a fire involving dynamite, nitroglycerin, or ammonium nitrate, all of which are considered explosive materials. The recommended strategy when there is the danger that a bomb or an improvised explosive device will be detonated is to stop firefighting and withdraw bystanders rapidly to a minimum of 2,000 feet from the site.

Explosion zones provide guidelines that can help us make good decisions with limited information. It is better to be safe than sorry when there is an explosion danger. Liquefied petroleum cylinder and tank explosions are a common danger to which firefighters are exposed when firefighting. Firefighters are killed each year when large propane storage tanks and trucks explode. Firefighters have been killed when operating a hose stream, wetting down exposed buildings, when such a tank exploded, and firefighters have been struck by a jagged pieces of steel tank. At one fire, large pieces of flying tank killed firefighters 230 feet from its original position when the propane tank exploded 18 minutes after the fire was reported and 8 minutes after the firefighters arrived on the scene. The explosion danger zone at large propane tank or truck fires should be over 800 feet from the fire. The National Fire Protection Association recommends all people, including firefighters, should withdraw 800 feet from a burning truck or stationary propane storage tank.

Collapse Danger Zones

When a wall is in danger of collapse, firefighters should be withdrawn from the unstable wall. The distance firefighters are withdrawn is called the collapse danger zone. A collapse danger zone is usually defined as a distance away from the wall equal to the height of the wall. For example, if the wall is 20 feet high, firefighters should be withdrawn 20 feet from the wall; if the wall is 35 feet high, firefighters should be withdrawn 35 feet from the wall. Some fire departments define a collapse zone as a distance equal to two times the height of the dangerous wall.

Flanking Hose Streams

When the collapse danger zone become a distance greater than the reach of the hose streams because the unstable wall is high, master stream or hose lines may be repositioned using a flanking strategy (fig. 1–3). Hose streams only have a reach of 40–50 feet, and streams from hose lines will be ineffective. Master streams may travel 100 feet. Sometimes, hose streams have to be repositioned using a flanking strategy for the safety of firefighters. Firefighters operating hose streams in a flanking position are stationed away from the front of the dangerous wall.

Firefighters and hose streams are stationed in front of exposure B or D.

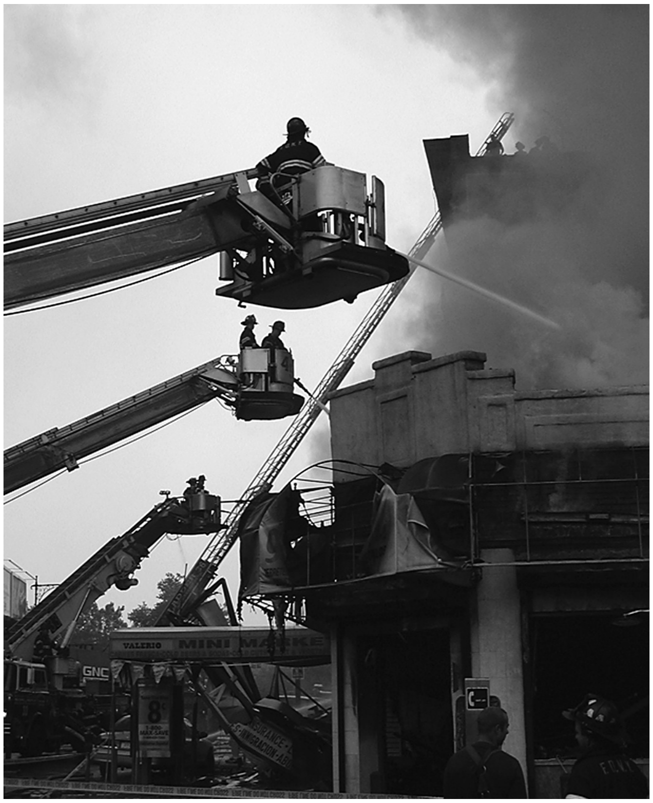


Fig. 1–3. Tower stream positioned outside the collapse zone.

Firefighters positioned in a flanking zone are positioned in front of adjoining buildings, away from the entire front of the unstable wall. The hose streams will be operated at angles from the flanking positions. The hose streams may be less effective owing to the angle, but the firefighters will be safe in the flanking zones if the entire front wall collapses.

Corner Safe Zones

There are four flanking zones, sometimes called *corner safe areas*, around a burning building. If you imagine, from a bird's eye view, the walls of a four-sided building collapsing and covering the ground with bricks, you will find four areas at the corners of the collapsed building that have fewer bricks. These are the corner safe areas. Incident commanders should order fire officers to position apparatus and operate hose lines in these flanking corners when there is the danger of walls collapsing. The probability of surviving a wall collapse is increased when in a corner safe area.

Postfire Analysis

A fire department should have a strategy for analyzing fire operations, in terms of new lessons learned and old lessons reinforced. After every greater alarm, a postfire analysis should be conducted. You learn something new at every fire you respond to, and by preparing a postfire analysis, so can everybody else. After a fire, incident commanders should assemble all the firefighters who responded to the fire or emergency and discuss the incident. The purpose is to learn lessons and share information. All firefighters should be able to learn from a fire or emergency—even one they did not respond to.

There are three parts to a postfire analysis: (1) a fact sheet; (2), a fire ground diagram; and (3) photographic documentation of significant factors identified in parts 1 and 2. (See chap. 20 of *Collapse of Burning Buildings*.) Everyone in a department can get information and experience from a fire if a postfire analysis is conducted. For every large or an unusual incident, there should be a study, an evaluation, and a record of the strategy and tactics used.

2 PREFIRE INSPECTIONS

Construction methods and building materials and code regulations are changing with lightning speed across this nation. New, renovated, and totally rebuilt structures bear little resemblance to older construction. Speed of construction, low cost, and lightweight structural elements that can be quickly moved into position are the number-one priority of builders.

Along with the removal of a building's mass, inherent fire resistance is sacrificed. The inherent fire resistance of older buildings that the fire service depended on is due to large structural elements that would take some time before they failed. This is called overbuilding and today is considered wasteful. A modern building's lightweight structural elements take less time to burn and lose strength. They collapse faster during a fire.

The fire service must realize that design professionals and the construction industry are not going to change the way they build structures. Instead, the fire service must change. We must inspect and preplan for fires in all buildings in our community. We must do more to understand new, lightweight building designs and their collapse dangers. Also, we must change the way we fight fire: We must use defensive methods of firefighting. We must know which buildings are safe to operate inside during a fire and which buildings are not safe to operate inside during a fire. There is only one way to find out about a building's stability and fire resistance. That is by inspections during the construction stage and, for present buildings, by conducting prefire inspections (preplanning).

The fire chief cannot determine structural stability with a size-up from the command post. The fire service must conduct prefire inspections of all buildings, as shown in figure 2–1, starting with new construction. Lightweight materials allow

Fig. 2–1. A chief conducting a prefire inspection.

fire to spread more rapidly than old, heavyweight materials.

Lightweight construction buildings, even those designated by building codes as fire-resistive buildings, allow fire to spread from floor to floor. By fire service standards, they are no longer fire resistive. The old definition of a building as fire resistive meant the building did not allow fire to spread from one floor to the floors above; however, new fire-resistive building construction allows fire to spread to floors above. For example, in 1970, New York City had a two-floor fire in a so-called fire-resistive building; in the 1980s, Los Angeles had a five-floor fire in a fire-resistive building; and in the 1990s, Philadelphia had a nine-floor fire in a fire-resistive building.

There is no such thing as passive fire resistance. Buildings alone do not stop fire spread. Every new-construction site must be visited so that firefighting preplans can then be drawn up. These inspections must consider not only fire hazards of the contents, but also the building design and construction materials used in the structure. Fire preplans must develop defensive firefighting strategies to compensate for new and old dangerous construction; for unusual, untested structural designs; and for lightweight building materials.

This defensive firefighting strategy should replace some of our old offensive firefighting strategies. The size-up experience developed by the fire service over the years no longer applies to modern lightweight building construction methods and designs. The following are specific examples of lightweight building materials and methods of fire protection and open interior design that are of concern to the fire service:

- ***Lightweight construction.*** One firefighter dies every 18 months in the collapse of a burning building constructed with lightweight wood construction. The widespread use of lightweight wood truss construction—and especially the connector used to fasten members of this light truss together—is a concern to firefighters. Instead of standard-size nails or bolts, trusses are connected using so-called sheet metal surface fasteners of random sizes and shapes. These sheet metal surface fasteners penetrate the wood surface by only one-quarter to one-half of an inch.

- ***Wooden I beams.*** Another new design in building construction is the wooden I beam, replacing the 2 in. × 8 in. solid wood rafter. This lightweight beam is composition wood beam, constructed of a 2 in. × 4 in., as a top and bottom flange attached to a piece of particleboard that acts as a web member. This composition floor and roof support is shaped as an I beam.

- ***Steel bar joist truss construction.*** The lightweight steel bar joist was used to support floors in the World Trade Center. This floor support is another form of lightweight floor and roof construction used throughout the country that has the fire service alarmed. When unprotected, lightweight bar joist beams can fail within 5–10 minutes of fire exposure (fig. 2–2). The World Trade Center, constructed by the Port Authority, to my knowledge, was the only high-rise office building in New York City to use lightweight bar joist construction in high-rise office building construction. I and many fire chiefs in the Fire Department of New York (FDNY) did not know lightweight bar joist construction had been used as floor supports in the World Trade Center. Preplanning would have informed us of the danger presented by this construction.

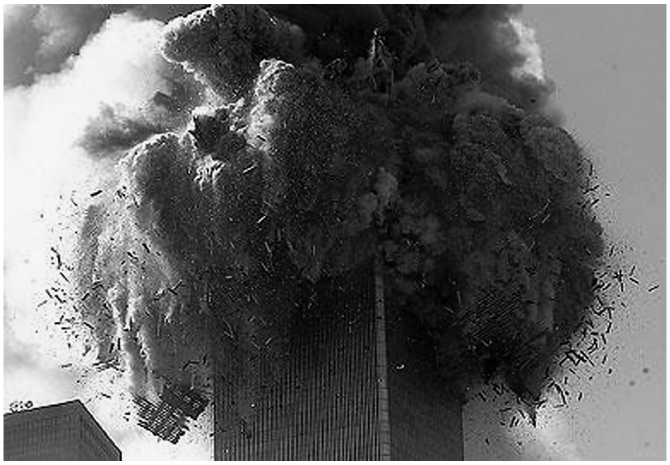


Fig. 2–2. Floors collapsing in the World Trade Center.

- ***Sheet metal C beams.*** Another type of lightweight construction for which the fire service must conduct preplanning for is the sheet metal C beam. This floor and roof beam is a thin piece of sheet metal bent in the shape of a long, thin C. This steel beam uses the bent shape to give it an increase in load-bearing capability, while reducing the actual amount of steel used in the steel member. Firefighters are holding their breath, waiting to see how this new structure reacts to fire and collapse.
- ***Fire protection of steel.*** Since the 1960s, builders have used spray-on fire protection covering steel. Instead of heavy concrete encasement, as used in pre–World War II fire-resistive buildings, a lightweight mineral fiber is sprayed on steel to protect it from fire. The change to spray-on fire protection of steel has been fought by the fire service ever since its introduction into the New York City building codes, for the following reasons:
    - The spray-on slurry is often not mixed properly
    - The steel is not prepared properly to allow the spray-on material to stick properly
    - Workers do not apply the spray-on material evenly
    - Other workers doing subsequent work nearby easily remove the critically important fire protection

  Preplanning must be conducted to determine which buildings have such inferior fire retardant, used for steel construction in high-rise and low-rise buildings (fig. 2–3).

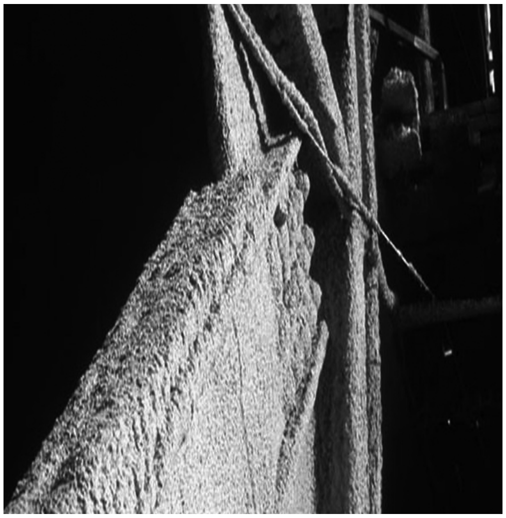


Fig. 2–3. Fluffy spray-on fire retardant on steel column.

- ***Large-area open-floor design.*** Client-driven architects and engineers have constructed buildings of a size that is beyond the control of firefighters using hose streams. These buildings contain 30,000–40,000 square feet of open floor space. Designers did not know or care that a typical fire company can extinguish only about 2,500 square feet of fire. If these building are not protected with automatic sprinklers, firefighters cannot extinguish a fire inside these large-area structures.

- ***Floor construction.*** The use of a four-inch concrete floor over corrugated steel I beams in high-rise office construction has failed at every serious fire in New York City. Floor steel beam supports sag, warp, and twist (fig. 2–4). The four-inch concrete floor above sags with the steel cracks and heaves. Smoke and flames spread to the floor above. Floor beams and concrete floor surface must be replaced after every serious fire. This started at the 1970s fire in 1 New York Plaza, where 130 steel floor beams were replaced and 20,000 square feet of concrete floor was removed. It continues to happen today. For example, in a fire in 1993 at the Bankers Trust building on Park Avenue, floors were seriously damaged and had to be shored up before firefighters could enter, perform salvage, and overhaul the smoldering offices. The question remains, is the problem the floor concrete or the inferior fluffy spray-on fire retardant used to coat the steel?

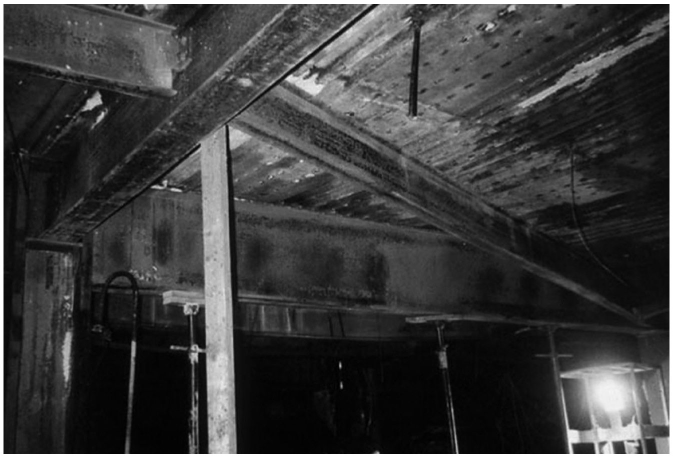


Fig. 2–4. Collapsing steel supports after a fire.

- ***Scissor stairs.*** The scissor stairway is another design innovation recently incorporated into modern buildings. The placement of two stairs within a single enclosure is a cost-saving measure that the fire service is concerned about, especially since stair enclosures can now be constructed of two layers of plasterboard, instead of masonry. In light of the 9/11 terrorist attack on the World Trade Center, building design professionals have said that they want to harden the construction of high-rise buildings. This is disingenuous because the fire service has seen these same people softening buildings for the past 50 years. The Federal Emergency Management Agency (FEMA), in its investigation, stated that a one design problem that may have cost lives at the World Trade Center was the stairways being clustered together in the core area.

Preplanning Computer Programs

In the fire magazines and at every fire conference all over this country, salespeople are selling expensive computers, with high-tech programs for prefire inspection. These computer programs feature dazzling graphics and color-coded animation. They have sound effects and visuals that can make fire and smoke come out of a building on a computer screen. Fire apparatus can move on the computer screen. Bells, sirens, and air horns blaring—even the noise of crackling fire—can be recreated in a realistic computer fire scenario.

What the salespeople don't tell you is that when you use their computer prefire inspection programs, you still have to go out and do the work. Fire officers must identify the target hazard, conduct a survey of the building, and draw a preplan that can be used in the computer program. A target hazard is a building or occupancy that is considered hazardous and requires special attention, such as increased inspections, prefire inspection, defensive firefighting procedures, fireguards, or an order to vacate the premises.

A fire officer will have to know how to inspect the preplan site and building and how to draw the building preplan diagram, identifying the size, construction, occupancies, and fire protection equipment the firefighters can use. After this work has been completed, strategies and tactics will have to be created on the basis of a potential fire or emergency in the building.

Most important, after the preplan is finished, it has to be programmed into a computer. The computer program you purchase at the fire conference may help you, but it will not do the work of creating a preplan for you. You still have to develop the fire preplan. A preplan consists of a fact sheet, with information about the building; a diagram of the building or floor; and recommended firefighting strategy and tactics. The preplan drawing and diagram should be a standard type used for every one of your buildings. In additional, standard symbols must be used to identify fire protection equipment and fire apparatus. Chiefs and company officers must not be required to figure out different types of drawings and symbols at a fire planning session or, more important, at a fire.

The preplan must also reflect your department's strategy and tactics. For example, the preplan has to incorporate your standard operating procedures and your department response assignment. The salesperson will not program your firefighting procedures into the computer; only you can do this. The computer program may look very impressive, but remember, what you put into the computer is what you will get out of it. It has to be relevant to your department—and as the saying goes, "Garbage in, garbage out."

Fire Preplanning

A fire officer has to know how to conduct a prefire inspection. The inspector will have to take notes and render drawings of the building site and all of the surrounding buildings. Every floor inside may need to be inspected, from the cellar to the roof. The fire officer should inspect and record the occupancies and hazards, and show what fire protection equipment is available.

Identifying the building

What is preplanning? The fire service is criticized for being too reactive, with not enough planning going on. They say we need to be more proactive, less reactive. For a start, every fire department should pick out the top 10 buildings in the district, or in the community, that are considered a fire challenge. After identifying these so-called target hazards, your department must draw up a fire preplan that can be used by all of the following personnel: your first responder, to assist in the size up; your incident commander, during a major fire; and your fire marshal, during a fire investigation. A fire preplan consists of making an inspection of the premise and filling out a fact sheet of information about the building, then drawing the building or floor diagram from a bird's eye view (or sometimes a profile view). Afterward, an experienced incident commander must devise the best method of fighting strategy and tactics for a fire in the building. There is nothing mysterious about fire preplanning.

The three parts of a fire preplan

The FDNY used to have a preplanning program called Tactical Information of a Perilous Situation (TIPS). When a fire officer conducting a routine fire inspection discovered a building with unusual hazards, it was recommended for the TIPS preplanning program. In brief, a fire officer reinspected the premises from the standpoint of a fire protection and firefighting strategy and tactics. During this prefire inspection, the fire officer noted the structure, the occupancies, and the hazards. Then, the fire spread features and the fire protection equipment in the building were evaluated.

After the site inspection was completed and notes and rough diagrams were compiled, the officer returned to the fire house to draw up a building preplan. This consisted of a fact sheet on the first page, listing information about the building and its owner, and a building floor plan on the second page, showing the relevant occupancies, content or process hazards, and most important, fire spread features created by the building and its content. Also included in this drawing were the fire protection equipment that could be used by firefighters. The inspecting fire officer left the third page of the fire preplan blank; this page was reserved for a summary of strategy and tactics, including recommendations on how to fight a fire, to be filled in later.

The preplan package, containing the fact sheet, the building floor plan, and a blank page for strategy and tactics, was sent to the local battalion chief. The battalion chief examined the document, went to the scene to evaluate the building and fill in the strategy and tactics to be used by the first responders and the incident commanders in the event of a major-alarm fire. A copy of the completed fire preplan was then sent to the deputy chief, who also conducted a size-up inspection of the building to approve the battalion chief's strategy and tactics.

These documents were reduced in size, photographed, and recorded on a small film called microfiche. A copy of the preplan was recorded on microfiche and was stored in a file box in the battalion and division car. There was also a photo enlarger/viewer in the chief's cars, to view the microfiche film preplan during a fire. At a fire, the preplan was retrieved manually from a file and, along with the photo enlarger, was brought to the command post, and the chief used it to assist in drawing up the strategy and tactics. This program was discontinued in the 1980s.

Electronic command board

McKinsey & Company, a consulting firm, evaluated the FDNY's response to the World Trade Center on 9/11 and recommended that the FDNY replace the magnetic command boards used by chiefs to track firefighters in a burning building. As a substitute, they recommended an electronic command board, which could track the locations of firefighters operating in a high-rise building and could also be used to store and display preplan information.

Today, New York University is designing a computerized command board, which could replace the magnetic command boards currently used by the FDNY for tracking fire companies. In addition, this electronic command board would have the capability to provide the chief with a fire preplan. The information provided on the computer would be similar to information programmed into the preplan.

A demonstration of the electronic command post board at New York University, was given to me and several FDNY fire chiefs. They wanted to collect information on how a computerized command board could be used in conjunction with preplans. The procedure for the electronic command board was as follows:

- As soon as the incident commander arrives at the scene and the command board is set up, the address of the building is fed into the computer by the communications dispatcher.
- An enlarged, bird's-eye view of the target premises is available at the touch of a button. The chief can view either the building or the fire floor on the computer screen. The surrounding streets and the interior layout of the building, as well as the exposure designations, can also be displayed on-screen.
- A large, easy-to-read floor plan provides important information on the floor layout for interior firefighting, including stairways, elevators, fire exits, standpipe connections, fire alarm boxes, windows, sprinkler-protected areas, sprinkler shutoffs, and storage rooms.
- All information put into the preplanning document by the fire inspector can be reviewed on-screen.

Even this high-tech electronic command board is only as useful as the information fire officers program into it. To effectively use electronic command boards, the FDNY will have to conduct prefire inspections once again. The information obtained through these prefire inspections can be programmed into a computer, instead of copied on film.

The missing link in past preplanning

The reason fire preplanning has such a bad reputation in the fire service is that most preplanning documents end up gathering dust on a shelf in some chief's office. Fire officers and chiefs know preplanning as something that requires a great deal of work, and they know that it is not effectively utilized in the fire response. It could be a waste of time except to the person who draws up the preplan.

If a fire ground commander realized some benefit from a firefighting preplan, there would be more planning in the fire service. Can this be changed? The answer is yes, and computers are the key; consequently, fire preplans can be more useful than ever before. Here's how:

- A computer dispatch system capable of storing preplans must be used.
- Computers must be in every fire apparatus that can receive and display a preplan document.
- A command board, to track fire companies, must be available to the incident commander at every fire. This command board must be capable of electronically receiving and displaying the preplanning documents.

Effective utilization of fire preplanning in the future

After a preplan is created, the document is given to a firefighter who can program a computer. The three-page preplan (described earlier in this chapter) is programmed into the computerized communications dispatch system. When an alarm is transmitted for the address of the premises that have a preplan, the alarm notification information is sent to the responding companies, and the dispatcher electronically transmits the preplan to the computer aboard the first-responding apparatus, to the incident commander's electronic command board, and to the office of the responding fire marshal (investigator).

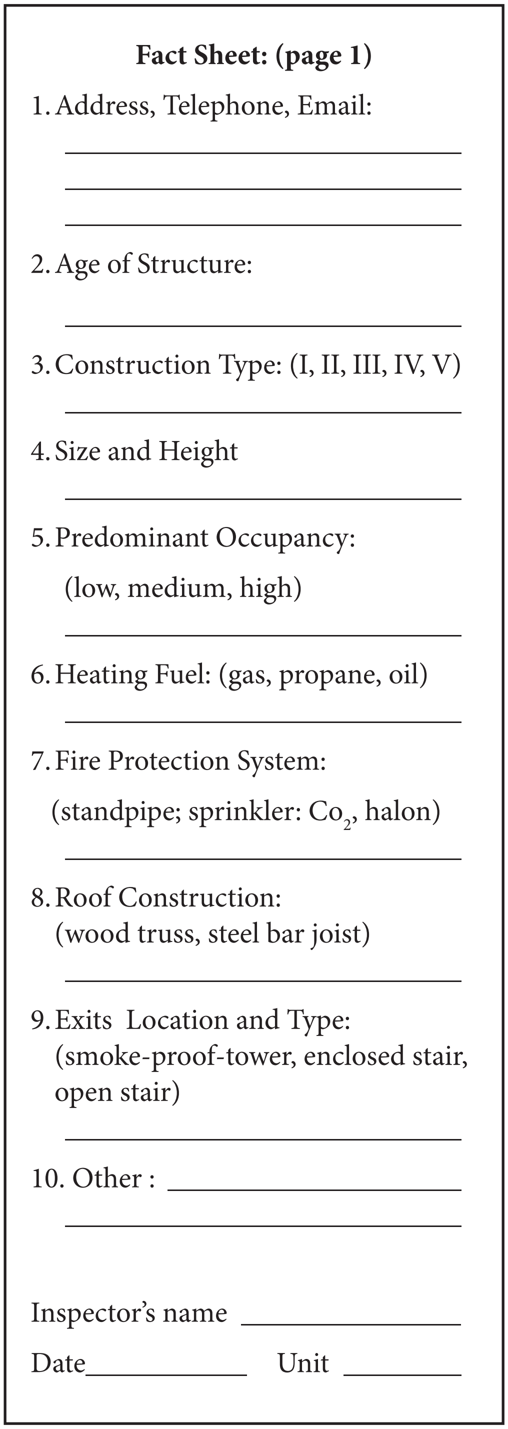
A quick glance at the third page, strategy and tactics, gives the first responder solid information—in the apparatus, before arrival at the scene of a fire—to include in his or her initial size-up of the building. The exact recommendations do not have to be blindly followed, but they will influence the first-responding incident commander's decision. If the fire is not controlled by the initial responders and a major fire develops, the subsequent fire ground commander who takes over will have had the preplan document sent to the electronic command board already, so that it is available as soon as the initial command post is set up. Here, the diagram of the building will be most valuable, for strategy and tactics. After the fire is controlled, when the fire marshal arrives on the scene, he or she will already have basic information about the premises and the owner, for assistance in the origin and cause phase of the fire investigation. If the results of a fire preplan are used frequently by these three important people, the significance of preplanning will be realized by everyone. Preplans will be done more often, and they will even be revised and redone as they are used and analyzed at fires.

Proactive Transmission of Fire Preplans

A key element in the successful use of fire preplanning is the responsibility of the fire dispatchers at communications headquarters. When an alarm is received for premises with a preplan document, the fire dispatcher must not simply announce over the radio to the first-responding officer, "Preplanning document is available." The fire dispatcher must start the ball rolling by instead announcing, "A preplanning document is being sent to the apparatus computer and the incident command board," and it must be immediately transmitted. The generally rule in the fire service is, if you use it at the small fire, it will be used at a large fire.

Example Preplan

Figures 2–5, 2–6, and 2–7 give an example of the documents comprising a fire preplan. They are intended only as a basic outline of the information required for a preplan. You should add, change, or subtract from this general preplan outline to adapt it to your community.



Fact Sheet: (page 1)

1. Address, Telephone, Email:

____

____

____

2. Age of Structure:

____

3. Construction Type: (I, II, III, IV, V)

____

4. Size and Height

____

5. Predominant Occupancy:

(low, medium, high)

____

6. Heating Fuel: (gas, propane, oil)

____

7. Fire Protection System:

(standpipe; sprinkler: Co_2, halon)

____

8. Roof Construction:
(wood truss, steel bar joist)

____

9. Exits Location and Type:
(smoke-proof-tower, enclosed stair, open stair)

____

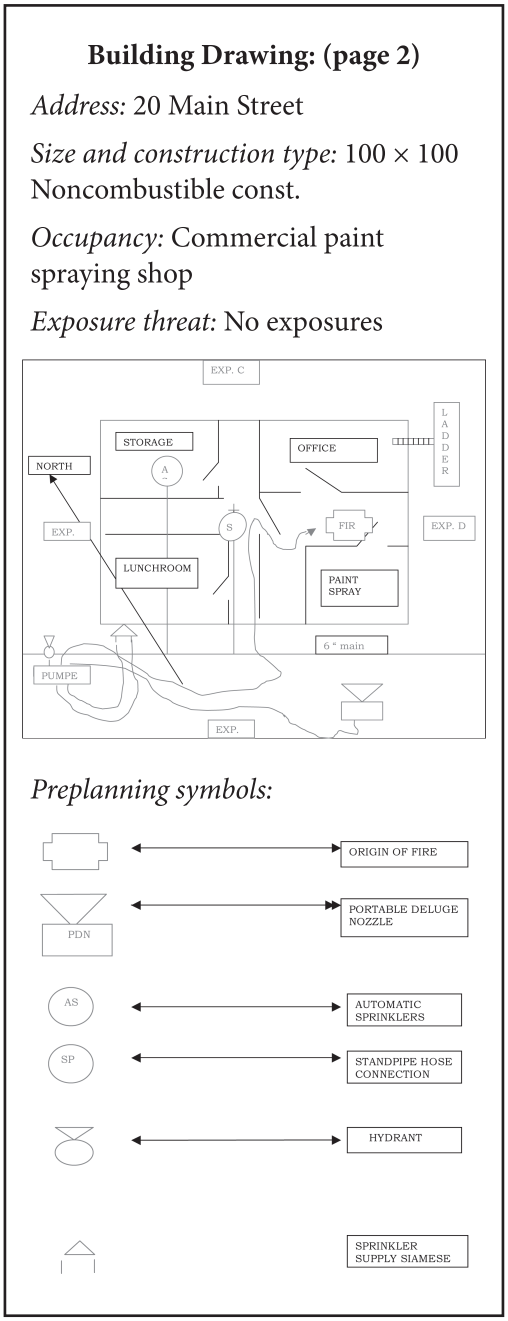
10. Other : ______________________

____

Inspector's name ______________

Date__________ Unit ________

Fig. 2–5. Fact sheet.



Building Drawing: (page 2)

Address: 20 Main Street

Size and construction type: 100 × 100 Noncombustible const.

Occupancy: Commercial paint spraying shop

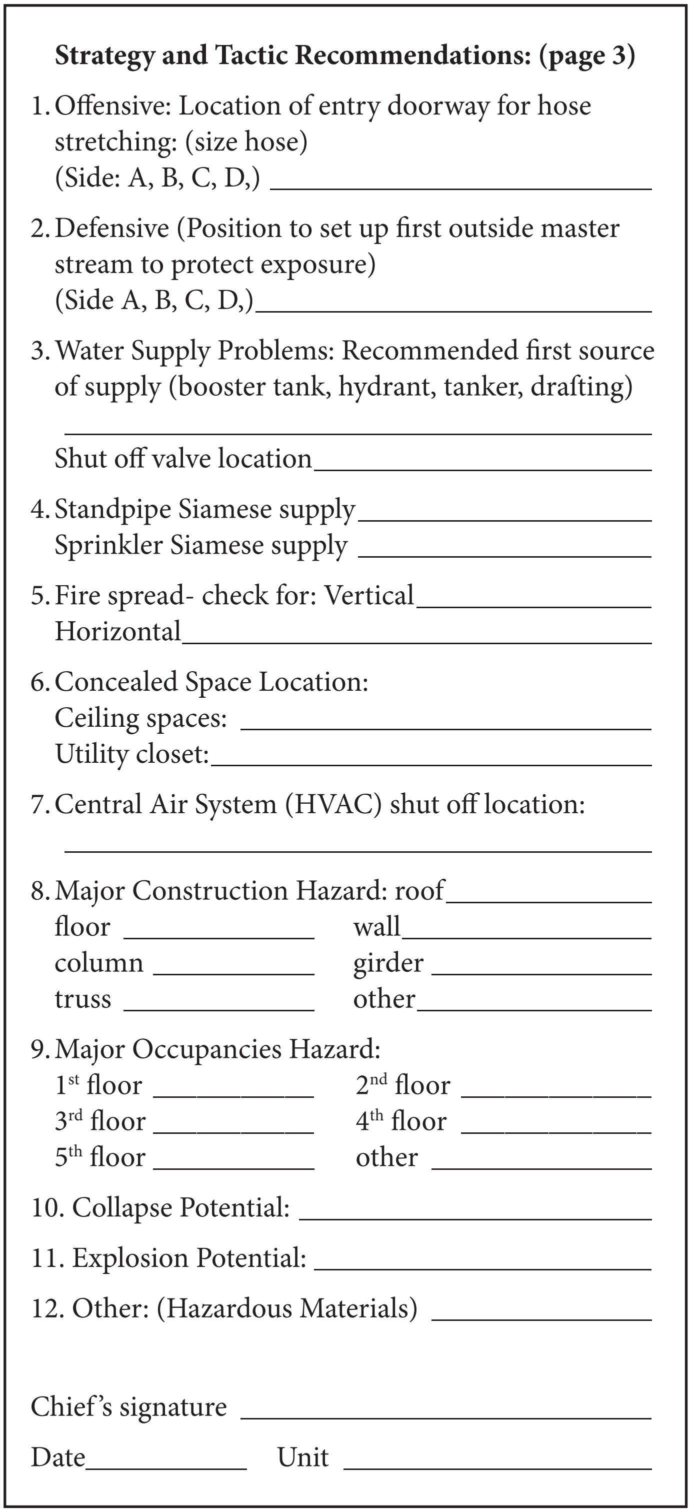
Exposure threat: No exposures

EXP. C
STORAGE
A
OFFICE
LADDER
NORTH
EXP.
S
FIR
EXP. D
LUNCHROOM
PAINT SPRAY
6 " main
PUMPE
EXP.

Preplanning symbols:

ORIGIN OF FIRE
PDN
PORTABLE DELUGE NOZZLE
AS
AUTOMATIC SPRINKLERS
SP
STANDPIPE HOSE CONNECTION
HYDRANT
SPRINKLER SUPPLY SIAMESE

Fig. 2–6. Building drawing.



Strategy and Tactic Recommendations: (page 3)

1. Offensive: Location of entry doorway for hose stretching: (size hose)
   (Side: A, B, C, D,) ____________________________
2. Defensive (Position to set up first outside master stream to protect exposure)
   (Side A, B, C, D,)____________________________
3. Water Supply Problems: Recommended first source of supply (booster tank, hydrant, tanker, drafting)
   ____
   Shut off valve location_________________________
4. Standpipe Siamese supply______________________
   Sprinkler Siamese supply ______________________
5. Fire spread- check for: Vertical_________________
   Horizontal___________________________________
6. Concealed Space Location:
   Ceiling spaces: _____________________________
   Utility closet:_______________________________
7. Central Air System (HVAC) shut off location:
   ____
8. Major Construction Hazard: roof_______________
   floor ______________ wall__________________
   column ____________ girder ________________
   truss ______________ other_________________
9. Major Occupancies Hazard:
   1st floor ____________ 2nd floor ______________
   3rd floor ____________ 4th floor ______________
   5th floor ____________ other ________________
10. Collapse Potential: _________________________
11. Explosion Potential: ________________________
12. Other: (Hazardous Materials) ________________

Chief's signature _____________________________

Date____________ Unit _______________________

Fig. 2–7. Recommendations on strategy and tactics.

3 SIZE-UP

As a new battalion chief, I wondered, how am I supposed to size up a burning building if I have to stay outside, at the command post? The deputy chief of my shift wanted me to set up a command post at the front of the fire building and be there if he responded to the fire (fig. 3–1). My orders were to stay at the command post to give incoming units orders. At the command post, I was required to brief the deputy responding to the fire on the progress up to that time, have a face-to-face transfer of command, and then be given orders by the deputy to enter the building and operate as a sector chief, wherever there was determined to be need.

Staying at the command post was difficult when I was a new battalion chief. Having only recently been a company officer, I was used to being inside the burning building, close to the action. This was a dramatic change; however, over the years, as a battalion chief and after being promoted to deputy chief, I slowly learned how to size up a fire from the command post. This chapter provides strategies for directing a fire operation from a command post, outside a burning building, in the street.

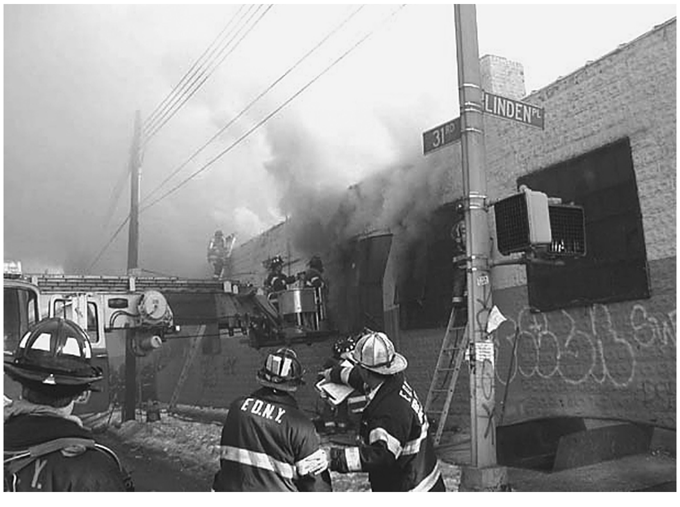


Fig. 3–1. Size-up of a fire and giving orders to incoming units.

Weather Conditions

If you are going to be denied the close-up approach of going inside a burning building for a (micro) size-up, you can get important (macro) size-up information from the very beginning of the response and en route. When responding to an alarm, be aware of the weather. Put on your turnouts outside the firehouse, on the apron. Check the flags blowing in the wind. Are people walking in the street bundled up and buffeted by the wind.

If it is a windy day, that could spell trouble. Wind spreads fire and sometimes blows fire and heat from a burning room back into the path of firefighters advancing a hose line. Conflagrations occur when the wind is blowing over 30 miles per hour. Wind affects firefighting more frequently than any other weather condition. In addition to stopping the advance of a hose attack team, wind blows smoke and burning embers toward exposed buildings. A strong wind also speeds up fire and smoke spread inside a common roof space. Fire will spread across an attic or cockloft more rapidly on a windy day. Coordinating venting and hose line advance should be accorded high priority on a windy day.

Temperature

If I could have only certain information about a fire operation, I would choose knowledge of the weather condition over knowledge of the interior fire size-up. I would want to know if the temperature is below freezing, and if so, I would want to know how many days has it been below freezing. One cold day is not as bad as a cold spell of four or five days. The longer the temperature is below freezing, the more things start to freeze. Nozzles have to be kept open to flow water and prevent freezing hose lines, and aerial ladders cannot be kept in the raised position for long periods because they will freeze up, requiring mechanics from the shops, to heat and retract the metal ladder sections.

On a below-freezing day, after water is used, the steps, sidewalks, and streets will become a sheet of ice. Firefighters will be injured by sliding and falling on the ice. Apparatus will skid and collide with other cars responding to the fire or emergency. You may not get the full assignment of apparatus and firefighters at the scene. Booster tank water may freeze, and freezing water in gas lines will cause apparatus to stall.

Such freezing-cold weather does not occur frequently in most places. However, that's exactly the problem. Because it does not occur often, when it does happen, we are not prepared, and the weather becomes more of a problem during a fire or emergency. Cold weather is not as much a handicap to firefighters in Alaska. They have experience and know how to fight fire at freezing temperatures. The strategy is to tell engines to keep the nozzles cracked slightly, to keep water flowing; pump operators are directed to spread salt or sand, to reduce fall injuries; and ladder company chauffeurs are directed to lower unused aerial ladders before they freeze.

Alarm Assignment Size-up

Knowing how many companies are responding to the fire is another piece of information that is more important than a look inside the fire building. When responding to an alarm, on the way to the scene, a fire chief should check the computer-dispatched alarm ticket and analyze the assignment to the box. Is the designated assignment full, or are some companies out of service for training or maintenance? This information may not be a problem at a small, routine fire, but if you encounter a large fire on arrival and if the original assignment is not responding, then you will have to call the dispatcher to fill out the assignment of missing companies. If this is the situation and you think you will need additional resources, tell the dispatcher early, and specify exactly what you will need. If there is a shortage of companies because there is another incident in progress, additional resources may be available only on a first-come, first-served basis.

Is a rescue company assigned? If you face an incident that requires specialized service of a rescue team, put in a special call for them.

Do I have a company assigned as a rapid intervention team (RIT)? Know which of the responding units is the RIT. The responding company may not themselves know their assignment, or the RIT team may want to work at the fire and forget to tell you.

If the regularly assigned companies are not responding, are there replacements companies filling in the assignment? If you have replacement companies that are not familiar with the local buildings, locating a fire may take longer, and the initial attack hose advance may not be as effective.

Is there a signal indicating an undermanned company is responding? If so, your hose stretch may take longer, or you may have to team two companies up to get the hose line stretched. By contrast, if on arrival you see your incident does not require the full assignment, immediately tell the dispatcher which units are in service for additional alarms. In case responding assignments are not complete during a fire, radio messages should be monitored closely for signs of problems, and alarms should be quickly transmitted at the first sign of fire spread.

Corner Command Post

If you are going to stay outside at a command post when arriving on the scene of a fire and the fire is in a corner building, then you should set up the command post at a corner, so that you can see as much of the fire building as possible. From this position, you can see two sides of the building. From the command post, I would want to see the fire and smoke coming from windows of the building. Sometimes, a person would be at a window; if so, the incoming ladder company could be given specific instructions, over the radio, telling where to position the ladder. At operations with a two-street view, you might see fire apparatus in one street that could be used at the side of the fire building. Also, fire escapes on the side of a building might be visible from the corner that could be used for stretching hose to the upper floors of a multistory building.

At some fires, from the corner command post, you would see the entrance side and observe the coordination and movement of the first attack hose team stretching the line, while also seeing the fire side of the building. After the stretch and call for water, you could follow the progress of the hose team as they extinguished flame in room after room. If you set up a corner command post where exposures A and B meet, do not change the fire ground designations; continue to use A as the front of the building when you communicate on the radio.

Smoke Size-up

The first and most important fire size-up factor that you want to check from the vantage of the command post is the smoke. If you stay at the command post, outside a burning building, you must use all your senses to size up the fire inside the building. At rare times, even the smell of the smoke at the command post may indicate what type of fire is burning inside.

Fire due to a smoldering mattress, food on the stove, or an oil burner can sometimes be detected by the smell of the smoke in the street. The smell of paint and wood burning in the street near the command post would indicate something more serious.

If there is no smoke odor in the street, identify the direction the smoke is blowing. This is another important size-up fact. In the daytime, visible smoke movement tells you which direction the wind is blowing, and the direction the wind is moving is the direction the fire will spread—inside and outside. This information helps determine where to position hose lines if and when you have to protect an exposed building from fire spread. The direction smoke is moving indicates a future exposure problem if the initial attack hose team does not accomplish their mission.

The color of smoke can also tell a chief at the command post important information. After firefighters vent windows and roofs, there is usually a large plume of smoke rising from the building. Smoke from a structure or content fire is often brownish or black in color. There are three stages to fire growth: first is the growth stage, in which the fire grows from a small area to engulf an entire room; second is the fully developed or active flaming stage, in which the fire engulfs the entire room; third is the decay stage, in which the flaming begins to subside and the temperature in the room decreases.

Black or dark brown smoke coming from a window indicates that the fire is in the growing stage (fig. 3–2). When flames blow out several windows, the fire has already flashed over, and you are present during the second stage of the fire. When the flames change to white smoke (steam), this indicates that the hose attack team is successfully moving through the building and extinguishing the fire.

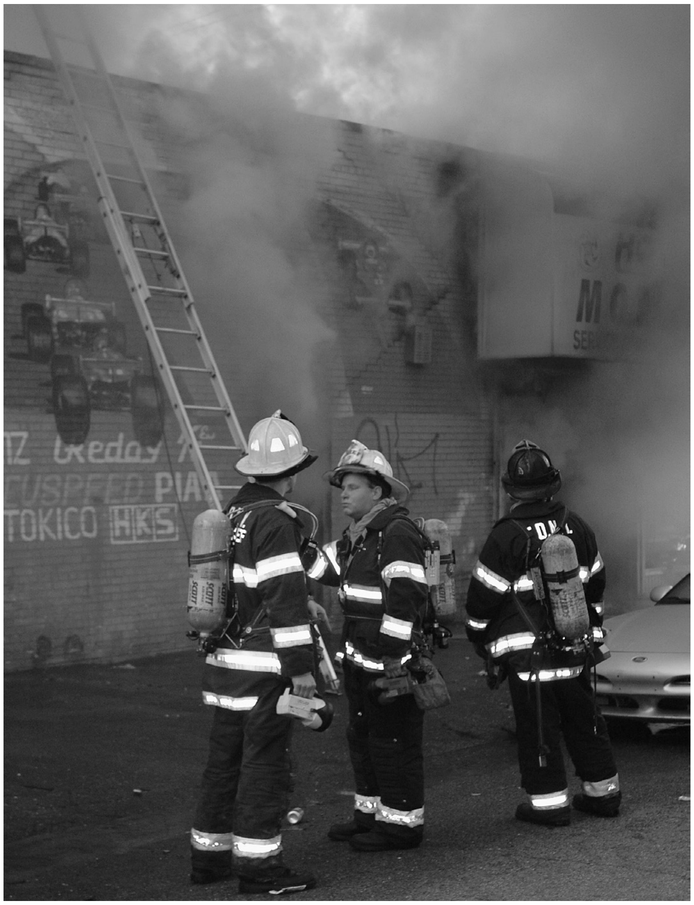


Fig. 3–2. Black smoke indicates fire increase.

Black smoke coming from a cellar or basement could mean an oil burner fire. Black smoke coming from one of the upper floors could be plastic furnishings or a flammable liquid used by an arsonist to start the fire.

Heavy black or brown smoke blowing out windows or doorways, before or during forcible entry effort, suggests the possibility of a smoke explosion. Smoke coming out a doorway or window, suddenly reversing direction, being sucked back into the building, is a further signal of a smoke explosion.

Smoke mixed with sporadic flashes of flame coming out of a doorway is called rollover. This could mean fire rolling over the heads of firefighters getting ready with a hose line to move into a store fire. It could also indicate that flashover is about to occur.

Active flaming from a vented storefront show window means that flashover has already occurred, and the danger that firefighters will be caught in a flashover or smoke explosion is lessened. Smoke and fire visible from the command post, in the street, coming from above the roofline after a roof skylight has been vented is also be a good sign. It means that products of combustion are not blowing back into the path of the firefighters inside who are advancing the attack hose line into the store.

However, if a steady smoke or flame comes out of a stripmall show window for too long a time, it may indicate that the hose attack team is failing to advance on the fire. Prolonged smoke and fire coming from a store with no change in quantity calls for some change of strategy. Start a second or third hose line, if that has not already been ordered, and start looking around for an aerial master stream to be repositioned nearby, for possible use at the downwind store.

When one is standing at the command post, the sight of a water stream by the advancing attack hose team shooting out the flaming window of a multistory building is a great sight. Moreover, it indicates success. A water stream sporadically shoots out a flaming window; it stops; then it shoots out again. Fire, coming out the window, turns to smoke; the stream stops. The next time, the water stream shoots out a little longer; it stops again. Then, the water stream shoots out continuously; the flaming window turns to white smoke, and the fire is being extinguished.

Hose Stretching

From the command post, an important size-up skill is to evaluate the coordination, control, and flow of the first-responding company, who stretch the initial attack hose line. From that vantage, a chief can verify whether the pumper is connected to a water supply. Furthermore, he or she can observe the hose stretch: Is it going smoothly, or is there a problem? Are there sufficient firefighters involved in the hose stretch? Four firefighters are required for a multistory hose stretch (in compliance with NFPA standard 1710 [the two-in/two-out regulation]):

1. Nozzle firefighter
2. Backup nozzle firefighter
3. Doorway/backup firefighter
4. Control/backup firefighter

All firefighters stretching hose should be working together. They should be evenly spaced from one another. There should be a call for water over the radio by the officer when the hose is stretched. The hose line should be quickly charged, with no burst lengths and no excessive hose lengths in the street. When you see this from the command post, 90% of the fire operation has been completed. This is good size-up information visible from a command post. If a chief ran ahead of the hose stretch and went inside the fire building and a problem occurred with the stretch, it could be a disaster. If the hose attack team advances on the fire without problems, all the other firefighting tactics—such as search and rescue, ladder placement, and venting—will also go smoothly.

Radio Reports

When you remain at a command post, you can determine a lot about the progress of the fire operation by using your portable radio. At many fires, by the time the chief arrives on the scene, the first hose line has already been stretched into the building, and other firefighters are performing venting, forcible entry, and search. When this is the situation, on arrival, the chief at the command post should immediately contact the (operations) officer of the first attack hose line by radio: "Battalion to engine 1, what do you have?" Listening to the reply to this communication gives a fire ground commander valuable size-up information. If the response is something like "Chief, we have fire on the second floor. As soon as we get water, we'll knock it down," then you can temporarily focus on other aspects of the operation. For example, is there an aerial ladder positioned for possible rescue or aerial master stream operation if problems occur and the initial attack fails?

You might also monitor messages between a firefighter assigned the roof vent position and the officer of the unit, such as "Captain, the roof is open." Also, sometimes you can hear a firefighter assigned the outside vent position on a ladder or fire escape give a radio message like "Ladder 2 to engine 1, let me know when you have water, and I will take out these windows." You may not see everything from a position outside, at the command post, but you can hear quite a lot from the command post by listening to a radio. This information gives a commander a sense of the entire operation.

Standard Operating Procedures

A response assignment for a structure fire in an urban or a built-up suburban community might be four engines and two ladder companies, a rescue, and a chief. Even if the chief is delayed, at most routine fires, first responders know what to do. If there is a standard operating procedure known by all companies in the department, that makes the chief's job at the command post much easier.

Some fire department standard operating procedures would have companies automatically proceed to prearranged positions inside a burning building. For example, when there is a standard operating procedure, a chief on arrival could expect the first and second engine companies to team up and stretch the first line to the fire. The second and third engines would report to the command post for their assignments.

Also on arrival, the chief could expect the first-arriving ladder firefighters to be operating be on the fire floor, with the officer after performing forcible entry, search and rescue, and venting. Firefighters would be going to the roof to vent the stairway scuttles and skylight serving the smoke- and fire-filled areas. Other firefighters, around the perimeter of the building on ladders or fire escapes, would be ready to coordinate venting with the hose line advance. After the fire is knocked down, other firefighters would be ready to go above the fire and search for trapped or unconscious people and examine for vertical fire spread.

Alarm Transmission

On arrival at an obvious structure fire, if anything looks or becomes out of the ordinary—such as a large body of fire on two or more floors, a hydrant out of service, a burst hose line, an explosion, people seen or reported trapped or found after jumping from windows—it should alert the incident commander to call for additional resources. Depending on the resources available to your department, any one of these problems might prompt an incident commander to request another engine and ladder to respond or transmit a greater alarm for more resources. This action would indicate a proactive philosophy of fire command. It would also be used to record the time of any catastrophic event occurring at the fire or emergency.

Communications from a Command Post

If you remain outside, at a command post, to find out what is going on inside a burning building, you must talk on the radio. Firefighters are not going to volunteer information. The command chief outside, at the command post, must request reports about the fire and the interior firefighting actions taken to extinguish the fire.

The first action of an incident commander should be to request certain information about interior fire spread from the operations officer inside the building. The operations officer may be a chief or an officer of the attack hose team or ladder or rescue company. This information depends on the type of building fire:

- At a private dwelling fire, a chief would want to know if a top-floor fire has spread to the attic.
- At a tenement fire, the chief would contact the firefighter on the roof and ask, "Is there fire in the concealed spaces?" Also, the chief would want to know if there were air or light shafts between buildings, because flames in a shaft may spread into the windows of an adjoining building.
- At a fire in a row of townhouses, from the command post, in front of the building, the chief might radio the roof firefighter and request a size-up of the condition at the rear of the building: Are people trapped at or jumping from rear windows? It is also important to know at a row of burning houses if fire has spread to the common roof space.
- At a top-floor fire in a large apartment house, the chief would want to know about fire spreading through the ceiling into the cockloft.
- At a strip mall fire, the chief at the command post should immediately contact the officer on the roof and request a report on the progress of roof venting. Are the skylights and scuttle covers open? Then, the chief should find out whether the fire has spread to the roof space over the stores. If fire has already spread into the common roof space over the stores, the chief at the command post would want to know from the officer on the roof whether there were any parapet (party) walls visible on the roof, one or two stores away on the downwind side, where a defensive hose line attack could be started; at this point, the chief would position hose lines on the roof. Next, the ceilings along the parapet wall would be opened and any poke-through holes would be sought. If the parapet wall does have penetrating holes through which fire could spread, another hose line would be positioned in the store; firefighters with this hose line would stop fire from spreading through the wall below the firefighters on the roof.

Incident Management from the Command Post

When directing a fire from a command post, establishment of an incident management system is critical. If a battalion chief arrived at the command post after I did, this chief would be assigned as operations officer and would direct interior firefighting operations. If the operations officer is on the fire floor of a multistory building, another chief may be assigned as a sector officer. This officer is usually assigned to operate on the floor above because fire spreads above me most often. Another sector officer or chief may be assigned to operate in the downwind exposed building. If there is a severe threat of fire spread or a greater-alarm transmission, additional sector officers or chief officers may be assigned around all four sides (A, B, C, and D) of the entire burning building.

Reconnaissance

In the fire service, we never say never. Nevertheless, in emergency work, there are exceptions. Sometimes a chief must leave the command post for an emergency. Absence from the command post should not be frequent or prolonged. My deputy had specific requirements for me, if I left the command post for any emergency. When I did go inside for some unusual event, I was instructed to have my driver, who was an experienced firefighter, stay at the command post. The driver had to know exactly where and why I was going inside. He was instructed to inform arriving companies to stand fast at the command post until my return. Also, if the deputy arrived at the command post, my driver was to inform him of my actions and my intended speedy return.

Avenues of Fire Spread

From the command post, a fire chief cannot see inside a burning building, but a fire officer should have a pretty good idea of what to expect from a building in the way of fire resistance and fire spread dangers, based on promotion study, building inspection, and fire experience. A fire chief does not have to go inside a burning building to know how a fire can spread. Fire usually spreads inside a building in the same way over and over again. There are common avenues of fire spread inside a building and means of fire spread associated with construction types. Common avenues of fire spread include concealed spaces, hallways, stairways, shafts, common roof spaces, through parapet walls, and from window to window. There is fire spread associated with different construction types, because of inherent weaknesses created by the different methods of construction.

Fire spread inside a building

For firefighting strategy to be effective, an incident commander must know the ways fire spreads on the inside of a building. The following sections describe how the products of combustion spread at a structure fire.

Concealed spaces. Most fires do not initially ignite a structure. Instead, the contents of a building are ignited and burn first, and then flames spread to the structure. Stuffed chairs, mattresses, clothing, and food cooked on the stove are items that initially burn. After the content fire is extinguished, the incident commander must have firefighters check for fire extension to the structure. As soon as possible after the knockdown of flame, the incident commander should order hooks

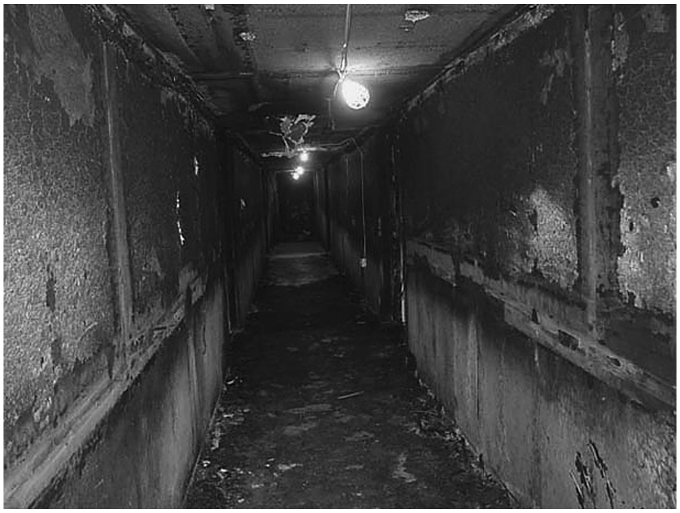


Fig. 3–3. Evidence of fire spread from an apartment to a public hallway.

to be used to open up walls and ceilings near the fire to examine concealed spaces. First, the ceiling directly above the point of origin is opened. The plaster around pipe risers is also opened, and the ceiling light fixture is pulled to examine the areas behind. Subsequently, poke-through ceiling holes are checked for fire spread, and the wall near a stuffed chair or couch is checked around the electrical wall receptacle. Fire may have extended into the wall.

As a test, an ungloved hand can be rubbed lightly across the surface. If it is too hot to touch, open the wall and check behind the plaster. If the wall is just warm, do not open it. When you open up a space and discover fire, you must act fast to cut off the flames. Have a hose line ready and quickly examine the concealed areas. For example, if you discover fire in the floor, open up the wall near it. If you discover fire in a wall, open up the ceiling above it. If you discover fire in a ceiling, open it up and check the baseboards on the floor above. If fire in concealed spaces has spread to two floors above, check the cockloft; fire may already be there.

Fire spread in hallways. When people flee a fire, they seldom take time to close the door to the burning room. When we arrive, flames are often spreading out into a hallway. Most fire spreads from a burning room through an open door, an unenclosed stair, a shaft, or an open window; it does not spread through concealed spaces as often as it spreads through these normal openings. At a serious fire, first-arriving firefighters usually come face to face with flames spreading out in a hallway, as can be seen by the damage in figure 3–3.

When there are no trapped victims, keep a door to a burning apartment or room closed. This action gives firefighters time to get the hose line attack and search teams ready for action. While waiting for the hose line to be flaked out and charged and to prevent the hallway flames from spreading overhead and igniting the paint, firefighters must attempt to control an open door by pulling it closed with a hook, a utility rope, or a gloved hand if the doorknob has not burned away. If the door cannot be closed, flames will spread along the hallway ceiling and walls, and if the attack hose line is not charged with water, firefighters will have to retreat down the hall to the stairs and descend several steps to get below the rollover flame. When the hose line is charged, advance back up the stairs down the hall and drive the fire back into the room of origin.

When rapid fire spread necessitates retreat down a hallway to the stairs, incident commanders must ensure that firefighters do not get separated and trapped on the hall side of the stair railing. They will not be able to get down the stairs, unless they quickly climb over the railing. During a chaotic period of the fire, as when flames are pushing firefighters off a landing, the incident commanders should ensure firefighters do not go up the stairs to the floor above to escape flames spreading out to a hall.

Stairway fire spread. In a multistory residence, flames spreading out of a lower-floor apartment into a hallway quickly travel up the open stairway, trapping anyone in the stair enclosure. One of the first safety and survival firefighting procedures we learn is to not get caught above a fire in a stairway. Going above an uncontrolled fire in a multiple-dwelling building is extremely dangerous. Incident commanders must instruct firefighters to never walk down a stairway from the roof, after venting the stair skylight or bulkhead door. Flames, heat, and smoke spread up stairways when the door to a fire apartment is opened. If the first attack hose line does not quickly move in and extinguish the apartment fire, the stairway can become a chimney.

Of the three types of heat transfer—convection, radiation, and conduction—convection is the most common way in which a structure fire spreads. Convection currents of heat and flame spread up a stairway. Convection is the transfer of heat by way of a fluid. A fluid is a gas or liquid. Fire gases such as smoke and flame are the method by which convection heat is transferred during a structure fire. For example, as air is heated, it expands and becomes lighter than the surrounding unheated air. This lighter air (flame and hot smoke) rises to the ceiling of a fire room and up a stairway. (Radiation occurs at a large conflagration and is defined as the transfer of heat through space. Conduction is the transfer of heat through a solid.)

Shaft fires. In older tenements, the light shafts, dumbwaiter shafts, and air shafts still exist. In renovated multiple-dwelling buildings, these shafts may be boarded up and concealed by plasterboard walls. The most serious shaft fire is one between two buildings. If the fire spreads into the shaft, two buildings are involved.

Several years ago, the FDNY and the Brooklyn Polytechnic Institute conducted tests in three-story row houses to study exactly how fire spreads in these buildings. Several of their tests involved interior shaft fires. In one experiment, a rubbish fire in the base of the shaft was ignited and allowed to burn freely. The shaft was between two buildings and open at the top. Windows faced the shaft. Flames spread rapidly up the shaft; fire leaped several feet above roof level. Fire extension into the building occurred first into the top-floor window opening, then the second floor, and finally the first floor. The highest temperatures within the shaft were registered near the top of the shaft.

What does this mean to an incident commander? It means that during a shaft fire, you must extinguish fire simultaneously at the point of origin and at the top floor. At least two lines are required at a shaft fire.

Cockloft fire spread. Why do some fires that extend to a roof space or cockloft, defined as the large concealed space between the top-floor ceiling and the underside of the roof deck, spread with explosive speed? There are three reasons for unusually rapid fire spread in a cockloft of a multiple-dwelling building or a row of stores.

One reason is arson. At an alarm for an odor of gasoline on the top floor of a large H-type dwelling several years ago, a firefighter searching for a source on the roof lifted up a vent and discovered four open one-gallon plastic containers that were filled with gasoline. The cloth wick extending from the opening of one container had only partially burned and had self-extinguished.

Another reason some cockloft fires spread unusually fast is old leaking natural gas pipes. Gas piping for gas lighting fixtures and cooking stoves sometimes runs the gamut—from top-floor occupancy, to occupancy through the roof space above the apartment, to large, old multiple-dwelling buildings. This old gas piping can develop small leaks over the years. Leaking gas can fill up a cockloft. When flames from a top-floor fire spread to the roof space, a rapid fire develops; sometimes an explosion occurs.

The third reason for a fast-spreading fire in a cockloft is the tons of exposed wood in the roof space. Dried-out wood beams, bracing, the underside of the roof deck, the ceiling lath, and wood furring can feed an explosive fire in the cockloft.

Whatever the cause of a rapidly spreading cockloft fire is, firefighters must realize that a top-floor fire that has extended to the cockloft is more dangerous than a fire on a lower floor. Ceiling and roof collapse can occur; in addition to rapid fire spread, if there is gasoline or gas leakage, there can be an explosion. Incident commanders should instruct firefighters to pull a top-floor ceiling near the room doorway. If the fire explodes the ceiling downward, an escape is possible, back out the doorway.

Concealed roof spaces that contain combustible framework, such as wood roof beams, wood furring, bracing, lath, and roof decking, are required by building codes to be subdivided by one-hour fire-stopping. The concealed roof spaces are subdivided into spaces of 3,000 square feet or less. This compartmentalization is designed to restrict the spread of fire in a concealed space such as a cockloft. But don't believe it. The fire stopping, which may include fire walls and party walls, often has poke-through holes that allow fire to spread. Workers often break through fire-stopping plaster partitions and even brick walls to run utilities through adjoining occupancies.

Parapet wall as fire division between buildings. A parapet wall is defined as a portion of a wall extending above the roofline. A brick parapet wall above a roof may appear to be in good condition. It may have new well-painted masonry, no missing bricks, and a new coping stone. However, if you go to the floor below and pull the top-floor ceiling along the wall or cut the roof deck near the base of the parapet and look into the cockloft, you may find a different wall, with missing bricks, large poke-through holes for ducts and wire, or cracked and crumbling mortar.

What you see above a roof is not what you get in the cockloft. When builders renovate a building, they rebuild the parapet wall portion of a party wall, above the roof deck. The important portion of wall designed to stop fire spread in the cockloft below the roof deck, however, may be left crumbling and unrepaired.

Window fire spread. If the heat of a fire breaks a window or a firefighter vents a window and the burning room is not extinguished by an attack hose line team, flames coming out of the open window can spread to the floor above or to an adjoining structure (fig. 3–4). Flames spreading from window to window, called *autoexposure*, must be considered a fire spread threat and a danger to firefighters. These flames can spread fire and trap a firefighter searching on the floor above a fire.

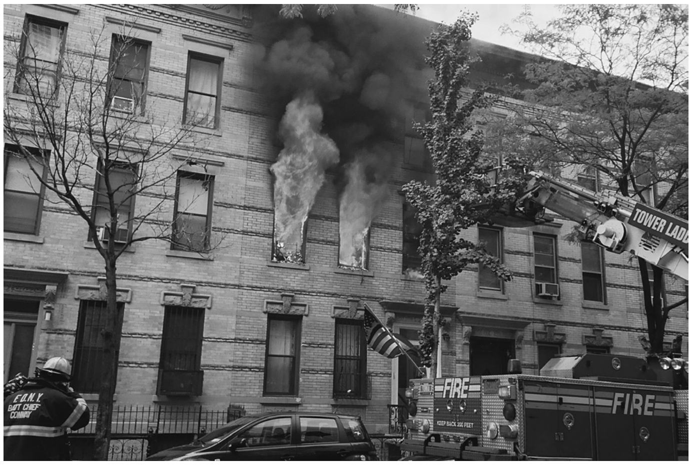


Fig. 3–4. Fire spreading from a window to the floor above.

A firefighter entering a floor from above can be trapped by autoexposure. When a firefighter is cut off by flames spreading up an interior stair, autoexposure can prevent the use of a fire escape or ladder. Incident commanders must coordinate window venting of a fire area. When there are no preliminary reports of persons trapped, windows to the fire area should be vented, thoroughly and quickly, when the attack hose line is advancing. Venting saves firefighters' lives and can prevent flashover and backdraft when timed correctly. However, if venting is not timed correctly, it can trap firefighters.

When flames spread from a window on one floor to a window above, firefighters may find themselves in danger. If an outside hose line is available, a quick dash of water not in a window but against the spandrel wall—the exterior wall between the top of one window and the bottom of the window above—may protect a firefighter trapped on the floor above by autoexposure. When a firefighter is trapped at a window and flames are coming out overhead, if no ladder is available, direct a hose stream into the window above the firefighter's head. This may keep the firefighter from jumping until a ladder can be positioned.

Fire spread and construction types

Five basic types of building construction are used throughout the United States. Building codes identify construction types by Roman numerals in books. The five types of buildings are:

- Fire resistive (type I)
- Noncombustible (type II)
- Ordinary (type III)
- Heavy timber (type IV)
- Wood frame (type V)

Some of these building construction types allow fire to spread more readily than others do. When we size up a building's overall fire spread hazard, we must look at both its contents and its construction. The materials stored inside (content) a building usually create the major fire threat. However, the structure also adds fuel to a fire. A building's construction type will also determine how fire will spread inside the structure, by way of concealed spaces, from floor to floor and to adjoining buildings.

The following sections describe reoccurring fire spread problems for each type of building construction. A fire chief standing at a command post should know these fire threats.

Fire-resistive building fire spread size-up. Fire-resistive construction (type I) was originally designed to contain any fire inside the building to one floor. This concrete and steel structure, called fire proof when first built at the start of the 20th century, did confine a fire by its construction. The fire containment provided by the structure is considered passive fire resistance. So-called active fire resistance is provided by sprinklers and firefighters' hose streams.

Today, fire-resistive building does not confine a fire to one floor. Passive fire resistance can no longer be depended on by the fire chief. Fire and smoke does spread several floors in a modern fire-resistive building, despite its steel and concrete structure. In the 1970s, New York City suffered a fire that spread two floors in a fire-resistive building; in the 1980s, Los Angeles had a high-rise office fire in a so-called fire-resistive building that spread four floors, from the 12th through the 16th; and in the 1990s, the Meridian Plaza fire, in Philadelphia, burned out the 22nd to the 30th floors. On September 11, 2001, the World Trade Center experienced a terrorist attack. After the plane crashes, smoke and fire spread rapidly throughout many floors of the towers. The fire continued to spread from floor to floor and was fed not only by the planes' fuel but also by the contents of the building.

Two avenues of fire and smoke spread in a fire-resistive building are by ducts of the heating, ventilation, and air-conditioning (HVAC) system, and by autoexposure, flames extending vertically from window to window. HVAC systems are used in fire-resistive buildings such as high-rise office buildings and hotels. A system of ducts acts as a network to supply warm or cool air. These ducts, unfortunately, allow fire and smoke to spread throughout a fire-resistive (type I construction) building. Some building codes require that the HVAC system automatically shut down when a smoke detector in the building is activated. However, the fire chief should not rely on code enforcement, so when standing at a command post, in front of burning fire-resistive building, a fire ground commander should order the HVAC system be shut down.

Autoexposure, the vertical spread of flames from windows below to windows above, is another way in which fire spreads throughout a fire-resistive building. To combat fire spread by autoexposure, the officer at the command post should order an aerial master stream into position to stop potential window-to-window fire spread. The chief at the command post may choose not to use the master stream, but it should be in position and ready to use just in case. A water stream directed against the spandrel wall, if present, can slow down autoexposure fire spread. Alternatively, if there is no spandrel wall, a fog stream may be used in an attempt to cool the glass window above. An aerial stream should not be directed into the flaming window if firefighters are inside.

Noncombustible building fire spread size-up. Fire spreads on the roof deck of a noncombustible (type II construction) building. A type II building has steel or concrete walls, floors, and structural framework. However, the roof covering is combustible; it burns and spreads fire along the top of the roof. The flammable roof covering of a type II building may be a layer of asphalt with a combustible felt paper covering. Another layer of asphalt may be mopped over another layer of combustible insulation paper. On top of all this may be a combustible insulation covering. When a fire occurs inside a type II building, flames rising to the underside of the steel roof deck may conduct heat through the metal and ignite the combustible roof covering above. Conduction is the transfer of heat through a solid. Once ignited, the asphalt, felt paper, and foam insulation may burn and spread fire along the roof covering. After a fire has been extinguished inside a type II building, the chief at the command post should immediately order the officer to go to the roof and examine the roof covering directly above for fire spread. If necessary, a hose line should be stretched to the roof for extinguishment.

Ordinary construction fire spread size-up. Ordinary (type III) construction has been described as a "lumberyard enclosed by four brick walls." Ordinary-constructed buildings have masonry-bearing walls, but the floors, walls, and roof are made of wood or other combustible material. The major recurring fire spread problem of type III construction is concealed spaces and poke-through holes. These voids, crevices, and openings through which smoke and fire can spread are found behind the partition walls, floors, and ceilings. These concealed spaces are created by wood studs, floor joists, and suspended ceilings. Poke-through holes are created by openings for utilities.

Today, there are even larger concealed spaces and large poke-through holes. Computers and electric wiring in modern building require large utility closets and shafts to run horizontal and vertical power throughout a building. Larger concealed spaces and larger poke-through holes allow a greater amount of fire to spread much faster throughout the building.

As soon it is reported that the main fire in a type III building has been extinguished, the fire chief should order the ceilings and walls around the fire room opened up with pike poles and the concealed spaces checked for fire. Firefighters must try to cut off concealed fire. The general rules for cutting off fire in concealed spaces can be summarized as follows:

- If firefighters discover fire in a floor, they open up the walls where the floor beam ends meet the wall.
- If fire is discovered in concealed space of a wall, open up the ceiling above the wall area of the concealed fire.
- If fire is discovered in a concealed space of a ceiling, open up the baseboards on the floor above it. By doing this, flame and heat can get ahead of the spreading fire and cut it off. The goal is to stop fire from spreading to the common roof space.

Heavy timber fire spread size-up. Heavy timber (type IV) buildings have masonry walls like type III buildings, but the interior wood consists of large timbers. The lumberyard inside is much greater. One difference between a heavy timber building and ordinary construction is that a heavy timber building does not have plaster covering the interior wood framework. Fire spread in concealed spaces is not a problem in a heavy timber-constructed building, unless it has been renovated, and plaster walls and ceilings have been installed.

If a fire in a heavy timber building is not extinguished by sprinklers or hose lines, the exposed wood surface of a heavy timber building can create a tremendous fire. After the windows break, radiated heat waves can spread fire across streets, igniting adjoining buildings. The chief at a command post must consider sending an early withdrawal signal, to get firefighters out of the heavy timber building during a rapidly spreading fire. A roll call should be conducted to ensure that all firefighters are accounted for, while at the same time, exterior master streams are being set up to protect exposures.

Prepare for the tremendous fire with flame and radiated heat spreading fire across streets. There will also be wind-blown flying embers and a building collapse after several hours. Fire apparatus will definitely have to be repositioned away from the expanding fire and radiated heat waves. Large water supply sources must be located, large-diameter hose lines must stretched, and master streams must be set up in flanking positions to protect nearby exposed buildings. The strategy should be to let the heavy timber building burn and protect any exposed buildings from fire spread. After several hours of fire, the structural framing (columns and girders) will fail; then, the floors will collapse, and next the masonry walls will crash into the street. Thus, a collapse danger zone must be designated.

Wood frame building fire spread size-up. Both the interior and the exterior of a wood frame (type V) building are combustible. A wood frame building is the only one of the five types of construction that has combustible exterior walls. There can be interior fire spread at the same time as exterior fire spread. When sizing up a fire from the command post, the chief must realize that the flames can spread throughout the building in concealed spaces, just as in a type III building; in addition, flames may spread outside, over the exterior combustible wall surfaces.

To combat fire in a wood frame building, an officer at a command post must order hose lines or master streams outside the burning building, as soon as possible after interior lines are positioned inside the structure. The exterior water streams are to stop fire spread on the outside combustible surface of the wood frame building. Outside streams are not used to extinguish fire inside the building, as long as firefighters are operating inside. Outside streams will also be needed to prevent fire from spreading to adjoining structures along the outer walls. The strategy of the fire chief at the command post is to position interior forces to extinguish the main body of fire, and then check for extension to nearby concealed spaces; if fire is discovered in these voids, the flames should be cut off before they spread up to the attic space.

4 WOOD-DWELLING FIRES

The story of the strategy of firefighting begins with the most common fire in America. The building where most fires in the United States occur and the most people, including firefighters, die as a result of exposure to fire and smoke is the 2½-story dwelling (fig. 4–1). This is the most dangerous structure built, from the standpoint of fire protection, because fire and smoke spread rapidly throughout the interior and exterior of these structures.

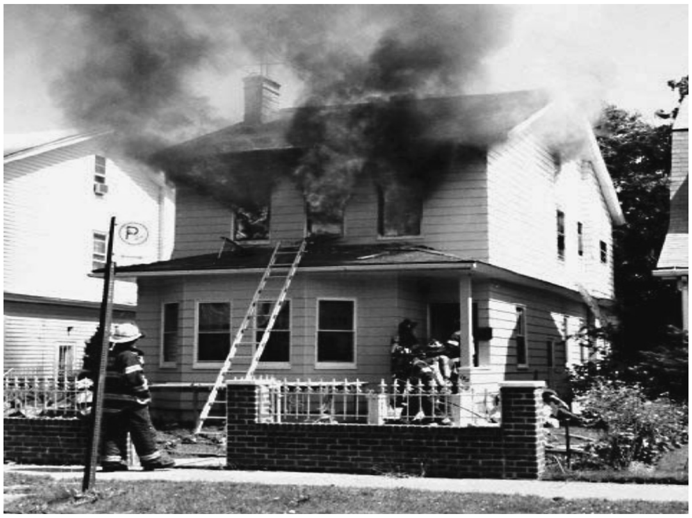


Fig. 4–1. Most fire deaths occur in private-dwelling fires.

Fire Spread

Interior fire spread problems are caused by the two designs of the dwelling structure: the open-floor design and the open stairway. The open-floor design of modern and renovated dwellings—that is, the absence of doors and partitions between rooms—allows rapid horizontal spread of flames. Older dwellings had doors and partition walls, which could stop fire spread from room to room. In modern dwellings and renovations of older dwellings, the doors and sometimes the partitions that separate one room from another room have been removed. Consequently, flames can spread rapidly between rooms and eventually throughout the entire ground-floor area.

Next, the main area of vertical fire spread will be the large open stairway. Most dwellings have a decorative open staircase that leads from the first floor up to the second floor and the bedrooms. Flames can quickly spread from the first floor—and sometimes from the cellar—by means of such an unenclosed (open) stairway. Firefighters searching second-floor bedrooms are sometimes trapped above the fire by fire spreading up an open stairway.

The fuel in today's dwellings has also changed for the worse. Wood, paper, cloth, cotton, and wool when burning create 7,000–8,000 British thermal units (BTUs) of heat per pound. Today's furnishings are made mostly of synthetic materials. Plastic furnishings create hotter fires. Polyurethane yields 12,000 BTUs per pound, and polystyrene yields 18,000 BTUs per pound. These burning plastics in furnishings produce high heat, much more smoke, and rapid vision loss because of the oil-based black smoke, which can in turn trap occupants and firefighters.

Hose Line Strategy

The first attack hose team of firefighters extinguishes most fires in America. The proper positioning of a hose line by the first attack hose team at a house fire saves more lives than any other single action. The strategy is to position a hose line between the fire and the people inside the building and extinguish the fire. To accomplish this, firefighters stretch hose in the front, side, or rear doorway and drive the fire out a window that has been vented by a firefighter performing outside venting. This is a proven strategy that is used by fire departments throughout the country. If the fire is too large to extinguish, firefighters operate the hose stream between the fire and the exits and try to temporarily stop the fire spread while occupants escape down the stairs. A second line may be needed to back up the first line, and if the first line extinguishes the blaze, the second hose line is repositioned above the fire to stop vertical fire spread.

Window Venting

When primary venting of smoke and heat from dwelling fires is conducted, the second-floor stair window at either exposure B, C, or D—usually located at the landing atop the stairway from the first floor to the second floor—is vented. This window will most effectively remove smoke building up on the second floor. It may also serve as an emergency escape route for firefighters, in case of a flashover or a backdraft. Which side of the dwelling this window is on can be quickly identified by a size-up of the front of the 2½-story dwelling. If the front entrance door is near the left side of the front of the building (exposure A), the second-floor stair window will be on the B-side alley; if the front entrance door is near the right side of exposure A, it will be on the D-side alley. Venting this window at the top of the stairway is just as important as venting a roof skylight, scuttle cover, or bulkhead door over a stairway in a multiple-dwelling building; this stair window can be vented immediately.

After the stair window has been vented, the firefighter assigned to outside vent must determine which room contains the fire and get to a position to perform window venting for the hose line advance. The outside vent firefighter should try to coordinate the venting of this window with the hose line advance. Vent the window at the same time as the hose line is charged and starts to advance. Timing this venting can be accomplished by radio communication with the interior hose attack team or by watching the hose line being charged with water pressure from the pumper. The hose jumps and straightens out as it is charged with pressure. A ground ladder will have to be positioned to the stairway window. A ladder may also have to be positioned to vent for the hose team advance.

Searching for Victims

Firefighters searching for victims should know the recurring locations in a house where victims are most often found. Victims are most often found unconscious or dead at the following locations:

- In the fire area or room of fire origin. Search this area first.
- In a path leading from a fire area to a door, a window, or fire escapes. Victims collapse while trying to escape the fire.
- In adjoining bedrooms, asleep in beds.
- In bathrooms.
- On the floors above the fire, overcome by carbon monoxide, a lighter-than-air gas drifting upward during the fire.

All portions of a house or apartment must be covered in the primary and secondary searches. However, we so often teach firefighters unusual locations where victims may be found that we sometimes overlook the locations where victims are most often found. There are usually no fire escapes on private dwellings, so people trapped at windows of second-floor bedrooms may have to jump out of windows. Don't forget to search the area around the perimeter of the building. When performing secondary searches, get information about occupants from neighbors to assist in determining who may be remaining in the building in need of rescue.

Exterior Fire Spread

Most fire spread after a fire department arrives on the scene occurs inside the burning structure—up the open stairs or in concealed spaces and spreading to the attic. As soon as a fire is extinguished, check the nearby concealed spaces and then check the attic. However, sometimes there is exterior fire spread in addition to interior fire spread. A 2½-story dwelling is most often a wood frame structure (type V construction), and this is the only one of the five construction types (see chap. 3) that can have a combustible exterior.

The outside of the building can be combustible wood, or asphalt shingle, or plastic siding. Flame can spread across the combustible exterior walls of a 2½-story dwelling, in addition to spreading on the inside. The siding may be wood or an asphalt imitation brick siding. The asphalt siding is an oil-based material. When it is heated by flame, small droplets of oil rain down the side of the building as the flames spread upward. The incident commander must always consider the need for an exterior hose line to stop exterior fire spread, in addition to the interior hose attack hand lines (fig. 4–2). A booster line or a quick dash with an outside master stream may be necessary. The outside stream should be used only to extinguish the siding fire; caution must always be taken to ensure that the exterior stream is not directed into burning windows, because such improper use of an exterior stream could scald or burn firefighters operating inside the burning dwelling.

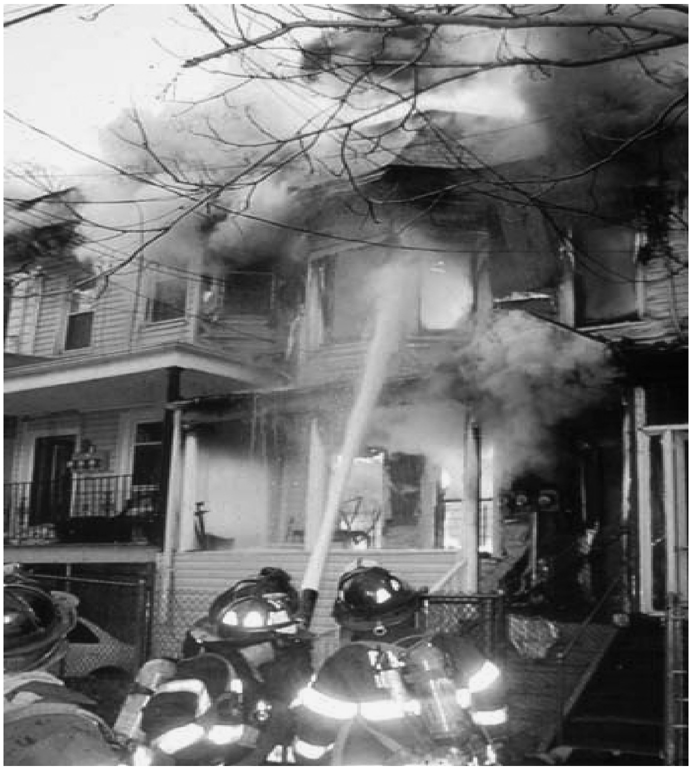


Fig. 4–2. Outside hose lines are required in addition to interior hose lines.

Radiation Fire Spread

Fire (heat) can spread by convection, conduction, or radiation. Convection fire spread is the transfer of heat by a fluid (gas or liquid). Fire gases spread heat at a fire; that is convection. The transfer of heat by convection can be seen when flames blow out a top-floor window, beneath a roof overhang, and spread into an attic. Fire spreading out a window, up to the underside of the roof eaves, is fire spread that must be stopped by an outside line; otherwise, there will be fire extension to the attic.

Conduction is the spread of fire through a solid. The most common heat transfer by conduction takes place when heat from a burning stuffed chair or mattress close to a wall is transferred through a plasterboard wall into a concealed space or void. After a fire is extinguished, first the ceiling above the fire is opened and checked for fire; next, the charred walls near the blaze are opened, and the wall space is checked for fire extension.

Radiation heat transfer is the transfer of heat through space. The transfer of heat by radiation does not occur as frequently as convection or conduction. Because it is unusual, because it happens suddenly, and because it is invisible, we are not as effective in preventing it from happening. Radiation heat transfer occurs from one 2½-story wood building to another across the space between buildings, over an alley or driveway. Burning wood buildings separated from each other by a space of 20–30 feet can still spread fire by radiation.

Fire spread by radiation cannot be seen. The heat transfer between buildings can be felt if you walk in the space between the buildings, but fire spread by radiation waves of heat is invisible from the command post. Not so with convection fire spread; heat transfer by convection can be seen, as the fire gases spreading heat are in the form of smoke or flame.

For example, while I was operating at a fire in a 2½-story building with a wood shingle roof fully involved in flames, radiated heat spread to an exposed building without notice. The adjoining building on the B side was approximately 10 feet from the burning building; the building on the D side was about 30 feet away. Smoke and heat engulfed the closer building, on the B side; it was almost invisible, owing to the large amount of smoke blowing in that direction. I ordered several hand lines into this downwind exposure building. Suddenly, I looked at exposure D, and noticed that all the wood window frames of the building were smoldering. I had been caught off guard by the radiation fire spread because it was invisible. I quickly ordered a tower ladder in position to protect the D-side building.

To stop radiation heat transfer, position hose streams in flanking positions, because you cannot get between the buildings. The area of radiation heat transfer will be too hot to enter. First, the hose streams should be directed to the exposed building to wet the initial fire areas. Next, switch the stream to the source of heat. If the water stream can quench the fire, your problems are over. If the fire is too large and the hose streams do not stop the flames, the strategy is to concentrate the hose streams toward the exposure. Do not waste water by using hose streams as a water curtain. Water curtains are the least effective method of stopping radiated heat.

Interior Fire Spread

Fire may spread inside a 2½-story dwelling up the large open stairway and in the concealed spaces of a *balloon-constructed* wood dwelling. The exterior walls in balloon-constructed wood dwellings have a 16-in. concealed space between 2 in. × 4 in. wood wall studding. This creates an unobstructed vertical space extending from the foundation sill to the attic. Any fire or smoke that enters this concealed wall space between the studs of balloon construction will spread to the attic. Any fire in a cellar, on the first floor, and on the second floor if it enters the concealed ceiling space can quickly spread to the balloon construction wall studding and then to the attic. An outside fire that burns through a wall can also get into the concealed wall spaces and spread to the attic. Any fire that burns through a ceiling can spread between the ceiling beams to an outer balloon-constructed wall space and spread to the attic.

To prevent fire spread in concealed spaces of a dwelling, you must try to cut off the flame with a hose stream before it gets to the attic. The strategy to stop concealed fire spread is as follows:

- If fire is in the floor, open up the floor beams where they meet the wall to cut off the fire with a dash of water. You should know the direction the floor beams run, as flame spreads in the space between the floor beams.
- If the fire is in the wall, open up the ceiling above the hot wall and quench any fire.
- If the fire is in the ceiling, get to the floor above with a hose line and open up the floor to cut off the fire.

Unfortunately, this fire cutoff strategy does not work in a dwelling constructed of lightweight wood truss beams. The fire will spread parallel between floor beams and also perpendicular to the floor beam. Flames spread along the truss beams and also through the truss web members. You cannot cut off a fire in concealed spaces of a truss-constructed dwelling. If it is a content fire in a truss roof building, go ahead and extinguish the blaze; however, if fire is in the structure, get the people out and conduct a defensive operation, because the collapse potential is too great.

Utility Shutoff

When a serious fire occurs in a private dwelling, the local utility company, electricians, and gas workers should be called to the scene to assist. In some large cities, the utility company workers automatically respond around the clock. At a serious structure fire where there is an outside attack strategy, live overhead wires endanger firefighters. The utilities will also have to be shut off before firefighters start overhauling. Structural damage can affect electric wires or gas piping. If utility companies do not respond around the clock, the utility company must train firefighters to perform this lifesaving function. At a serious fire, when utility companies are on the scene, the incident commander can order the gas and electricity shut off. A utility company worker can disconnect the wire at the nearby utility pole or underground. When extensive salvage and overhauling are necessary after a serious fire has been extinguished, the utilities should be shut off before the operation starts. By shutting off gas and electric supply, you remove the possibility of injury to firefighters by electric shock or gas explosion.

In general, during the initial stages of a routine house fire, the utilities are not shut off, because the lighting assists in search and there may be an insufficient number of firefighters on the scene. However, there are times when the electricity is shut off immediately on the arrival of the fire department. The electric supply will be immediately shut off when the electric wire is the cause of the fire. This is also the case if a person is being electrocuted or trapped by the arcing wires or if there has been an explosion or collapse and firefighters must search the rubble for victims. After a collapse or explosion, wires will be exposed in the rubble, and power must be removed.

Chimney Collapse

There are many parts of a 2½-story house that can collapse during a fire. Collapse dangers include the ceilings, porch, cornice, and chimney. Floors and roof—especially if the dwelling is of lightweight truss construction—can also collapse when weakened by fire (fig. 4–3).

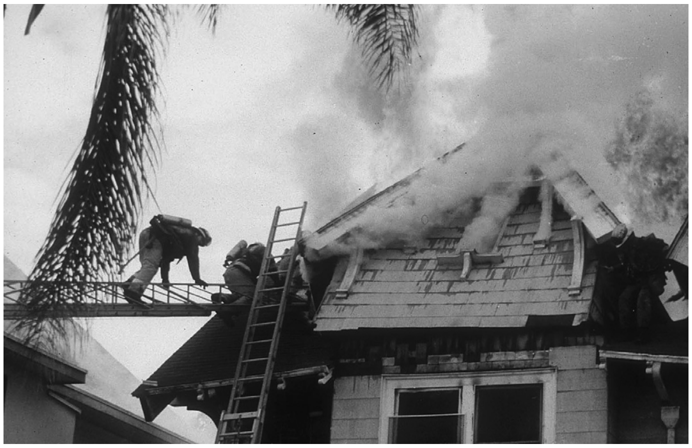


Fig. 4–3. A peaked roof poses a collapse danger at a private-dwelling fire.

One of the most overlooked and most deadly of these collapse dangers is the chimney. Chimneys can be collapsed by a gust of wind or with a hose stream. A collapsing chimney top can crush firefighters, or it may send the equivalent of wheelbarrow of bricks showering down on top of the heads of firefighters stretching a hose, with deadly consequences.

When sizing up a fire in a 2½-story dwelling on arrival, look at the chimney. How high is it? Does it lean to one side? Is the mortar missing between the bricks? Realize that when the roof burns away, much of the chimney support has been removed and you have a freestanding brick structure. This is a collapse danger. A leaning chimney on a house that has the roof damage due to fire should be approached with the same caution as a parapet wall at a burning row of stores.

Hose Stream Positioning

The first hose line is usually advanced through the front or side entrance and attacks the fire. A second hose line is stretched to back up the first attack team. However, if there is an adjoining building seriously exposed by flame coming from the main fire building or if there is fire spreading up the outside combustible siding, threatening to spread into the attic through a cornice or a roof overhang, then the second hose line may be stretched to control this exposure fire. In such cases, a third hose line is ordered to back up the first line. The backup hose line is often taken to the floor above or the attic, to cut off vertical fire spread, once the incident commander is sure the first line can handle the main body of fire.

When a fire situation is undetermined and conditions are fluid, a good, proactive hose-stretching practice is to have a company stretch a hose line to the front of the fire building near the command post and stand fast. By ordering a company to stretch a line to the front of the building and stand fast until you decide where the line goes, you have made the company officer find a pumper with a water supply, locate a nozzle and sufficient hose, and stretch it to the fire building. The company has carried out two-thirds of the hose stretch by stretching to the front of the fire building. Within this time, it may become clearer to the incident commander exactly where this hose line is needed. If the hose is stretched to the front of the fire building and fire conditions improve to the point at which there is no need for the hose line, the company can be directed to take up the hose line.

Autoexposure (Window to Attic)

One of the main objectives of the strategy employed at a house fire is to keep fire from spreading to the attic. Fire often spreads into an attic of a 2½-story house when flame coming out a top-floor window heats up the underside of an eave or cornice. (An eave is the edge of the roof of a building, which usually overhangs the wall; a cornice is horizontal molding projecting along the top of a building.) This exterior fire spread from window to attic is common in house fires. It can also occur when fire blows out of a lower-floor or basement window and travels up the combustible side of the building. The wood or asphalt siding of a 2½-story house spreads fire quickly. When the flame reaches the underside of an eave or cornice, it quickly penetrates the often rotting or dried-out wood boards there, or it goes through small cracks and spreads into the attic. A fire ground commander must always be aware of this fire spread possibility.

A firefighter with a booster hose line may direct a stream to prevent outside fire spread up the side of the building. An aerial platform positioned at the downwind side of the dwelling can have the ladder available to protect an adjoining building, and the ladder may be extended to a nearby window to quench any fire before it involves the attic. Just as the strategy at a strip mall is to stop the fire from entering the common roof space, the strategy at a 2½-story–dwelling fire is to stop fire from entering the attic space.

We are taught in rookie school that there are six sides to a fire. We are trained to ensure that fire is stopped from spreading to any of these six sides. The six fire spread sides of a fire that we must be concerned with are as follows:

- Upward fire spread, through the ceiling
- Fire spread to the four sides, through the enclosure walls
- Downward fire spread, through a floor board (e.g., at an arson fire)

However, in a fire at a 2½-story wood dwelling, there is a seventh side of a fire with which we must be concerned. The seventh side of the fire is the combustible outside walls. Flames often spread along the siding along the outside surface of the burning dwelling. Don't forget that we must also stop fire from spreading to this seventh side of a dwelling.

5 STRIP MALL FIRES

Strip store fires are difficult and dangerous to extinguish. A major construction defect is the common roof space. This construction defect allows fire and smoke to spread fire over all of the adjoining stores. The common roof space—along with suspended ceilings, large quantities of flammable material, lack of side ventilation opening, and limited access from the rear of a strip mall store—is a major reason why fighting fire in strip malls is difficult and dangerous.

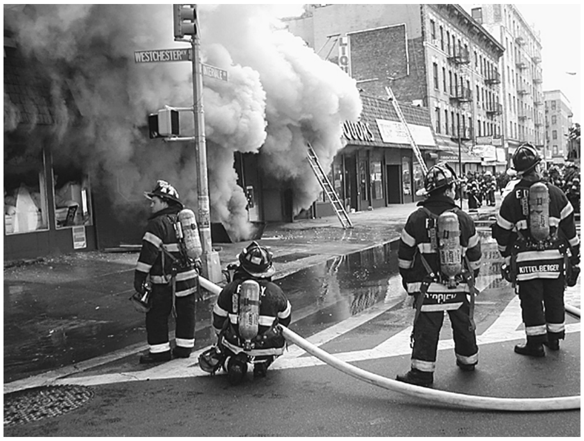


Fig. 5–1 A strip mall fire is more hazardous than a private dwelling fire.

When you inspect a strip mall, there is no standard room layout from store to store. Each occupancy may be a different size and shape. A row of stores may have several explosion hazards created by the materials inside or the use of the occupancy. Explosions in stores may occur during a fire owing to cooking with grease, gasoline stored in automobiles, garden fertilizer, household paint, paint spraying, furniture refinishing, and propane storage.

A strip mall fire is a dangerous fire. There is also a danger of collapse in a row of stores from parapet walls, marquees, canopies, cornices, ceilings, trapdoor openings for cellar stairs, and floor cave-in due to heavy loads. Beware! Strip mall fires are more dangerous than residence fires (fig. 5–1).

Locate the Fire

The first strategy of the incident commander at a strip mall fire is to locate the fire. Find out which store contains the main body of fire. This is easier said than done. At night or on holidays, when the stores are closed, several of the stores may be filled with smoke; if so, look inside all the glass store windows for flame. If there is no visible flame, the store that contains the greatest amount of smoke usually is the main fire store. If several stores contain heavy smoke, look for the store with heat condensation stains on the inside of the glass entrance door or windows. The heat of a fire will create condensation on the inside of a store window during a cool night. In storefronts covered with iron security shutters, if the glass of the store has broken from the fire, there may be heat discoloration on the steel shutters. Finally, always check the cellar of the store; a store fire may have started there.

Sometimes, firefighters operating on the roof can determine which store contains the fire by examining the amount of smoke coming from skylights, roof vents, or a rear door. A radio message from the incident commander requesting a size-up from the firefighter assigned to the roof can help determine or confirm the exact fire location in a row of stores. When several closed stores in the row have locked security gates or shutters covering storefronts, consider forcible entry of both exposure stores. As soon as possible after the fire store has been identified and entered and the fire has been located, open the adjoining storefront gates and shutters, because fire in the common roof space over the stores can spread rapidly. Open the stores on each side of the fire store, starting with the downwind store. Eventually, these stores are going to have to be checked for fire spread.

When it comes to opening metal security gates, be proactive; do not wait for fire to spread to adjoining stores to begin forcible entry (fig. 5–2). You do not want to play catch-up with a fire, chasing it with metal gate forcible entry. An entire row of stores can burn if you do not open all the security gates in time. At a serious fire, where fire and smoke are already spreading throughout the common roof space, one company can be assigned specifically to open every gate and shutter on the entire row of stores during the initial attack. Opening all the steel shutters in the row of stores will allow quick and easy access for fire size-up, hose stretching, and ceiling pulling with pike poles. If the fire spread gets ahead of forcible entry of steel shutters, a defensive operation will be required, using master streams.

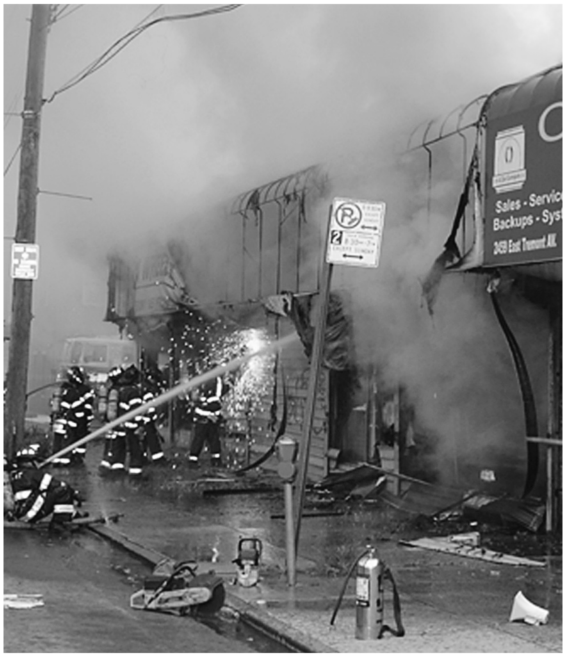


Fig. 5–2. Be proactive when opening security gates at a strip mall fire.

Cellar Fires

After the store of fire origin has been located, open any existing sidewalk cellar entrance doors and check the cellar for fire. In some instances, a fire starts in the cellar and burns up to the first floor of a store. If the fire starts in the cellar and is not detected and you are fighting it as a store fire, the floors may collapse and kill firefighters by plunging them into a burning cellar. Also, if the cellar fire is not detected on arrival, the fire may spread to adjoining store cellars before the incident commander realizes it.

To quickly check the cellar for fire, look for a metal entrance door off the sidewalk. After being forced open (e.g., by forcing a padlock), these sidewalk cellar entrances may give access to the cellar. Firefighters entering a cellar to check for fire through a sidewalk cellar entrance should be aware that the entranceway may have unusually steep and dangerous stairs. Wood steps leading to the store cellar may be rotted, or the cellar masonry entrance may have steep risers and narrow treads. There is often a conveyor belt or slide used to transfer merchandise from trucks at the sidewalk to the store cellars; firefighters blinded by smoke could fall down a cellar slide or conveyor belt. When smoke is billowing up a sidewalk entrance door and you must go down the stairs to check for fire, use caution when descending. Also, after a sidewalk cellar stair door (or doors) has been opened, a serious fall hazard exists; at night or when visibility is low owing to smoke, firefighters can fall into the opening. Protect the opening with a barricade of a ladder, or rope off the area after opening sidewalk cellar entrance doors. If the fire is in the cellar, leave the sidewalk cellar doors open during the fire operation to vent the cellar and check the adjoining cellars for fire spread and for avenues of attack. Cordon off the cellar entrance to prevent fall injuries.

Interior Fire Spread

Reoccurring avenues of interior fire spread in a strip mall include concealed spaces behind plaster walls, ceilings, and the common roof space. When the fire has been found to be in the cellar and after the main body of the cellar fire is extinguished, fire officers should open up the concealed spaces around the fire area. Use pike poles to open up the ceiling and walls near the fire. In many store cellars, there are no ceilings, only the open joist of the first floor. If there is no ceiling, fire can spread up from the cellar quickly.

If fire is found inside a partition of a cellar wall, go up to the store above the fire and open up the walls to ensure that fire is not traveling up the wall through concealed spaces to the common roof space. If a fire occurs in the basement of a strip store, it is good practice to immediately go to the first floor and open up the partition wall above the fire. If there is a large fire in the cellar, open the first-floor wall partition separating the fire store from the nearest adjoining store. The partition wall between two stores should be checked for vertical fire spread while the cellar fire is being extinguished. If flames spread to the common roof space, they can quickly spread horizontally over several stores. If available, a thermal-imaging camera should be used to detect fire in the concealed space.

When using forcible-entry tools to check for fire behind walls or ceilings, the question is often asked, how much of an opening should I put in a wall or ceiling when checking for fire, and when will I know to stop opening up the ceiling tiles or the plasterboard walls? The answer is that to examine for fire spread, open up walls and ceilings until you see clean (uncharred or unburned) wood or metal inside the concealed space.

Venting

One of the most important firefighting strategies an incident commander can use to stop fire in a strip mall is roof venting. It is almost as important as positioning the hose lines into the stores. A ground ladder should be placed in front of an adjoining store on the upwind side of the fire. A firefighter should go to the roof, and if there is no danger of roof collapse, first remove the skylights or scuttle covers that serve the fire store. This will release the smoke out of the store. It is not necessary to time this roof venting with the hose attack. This venting will remove smoke from the store, improve visibility, and help the search for fire spread and victims. It will assist the advance of the first attack hose line into the store. Venting the skylight will also reduce the chance of a backdraft explosion if there is an explosive mixture inside. Even if an explosion occurs, some of the blast will be diverted up and out of the store through the vents, away from the firefighters advancing the hose line. Also, by eliminating the heat and smoke from the store by roof venting skylights and scuttles, it may delay a flashover.

Common Roof Space

The number-one strategy when fighting a fire in a row of stores is to keep the fire from getting into the common roof space. In a strip mall, there usually is a common roof space extending over several attached stores. Often, there are no fire partitions in the common roof space separating the stores, or if partitions are present, they are punctured by utility openings that will allow fire. to spread. If fire spreads vertically in a concealed space up to the common roof space over one store, the flames may then spread out horizontally throughout the common roof space on both sides, and if not stopped by firefighters, it will destroy all the stores in the row. Thus, the primary objective in stopping fire spread in strip malls is to prevent fire from getting to the common roof space; if it gets into the common roof space, then the objective becomes to keep the fire from spreading horizontally over adjoining stores.

There are many ways in which fire spreads to the common roof space. Flames may burn through the ceiling tiles; flames may spread up a partition wall; flames may burn through a ceiling poke-through hole; flames may spread up through a utility closet; flames may spread up through a light fixture; or flames may flow out of a store window and up through the eaves. If the firefighter operating on the roof determines that flames (not just smoke) have spread to the common roof space, the incident commander should be notified and permission should be requested to cut a vent opening in the roof.

When fire is discovered in a common roof space, the roof deck should be cut open to vent smoke and heat. Firefighters should cut a vent opening as close as safely possible over the spot where the roof space fire is burning and attempt to push down the ceiling, to create airflow from burning store. The purpose of the roof deck cut is to let the heat, smoke, and fire rise out of the common roof space and store and to delay its horizontal spread to the adjoining stores long enough to allow firefighters to position hose lines into the adjoining stores below, pull ceilings, and extinguish the fire in common roof space from below. The incident commander should order an aerial ladder positioned downwind from the fire store. An aerial master stream may have to be used if the interior attack fails. Another master stream may have to be positioned upwind (fig. 5–3).

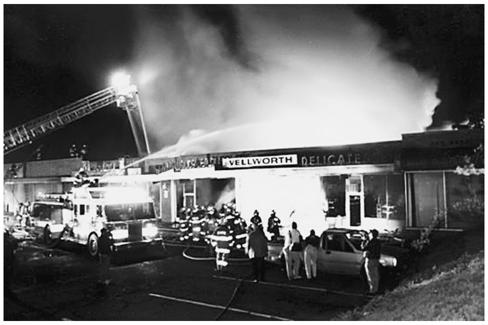


Fig. 5–3. Aerial master streams may be required in order to control fire spread in a common roof space.

There are three types of roof venting that firefighters perform in response to strip mall fires:

1. ***Skylight opening***. The skylight and scuttles can be opened immediately, as long as doing so will not cause fire to spread to adjoining higher buildings. Skylight and scuttle cover venting removes smoke and heat from the store, not the roof space. This is primary venting, and it may be all the venting that is required.

2. ***Roof cut over the fire.*** Roof deck cut venting should be directed only when fire is confirmed to be in the roof space. Do not cut a vent opening in a roof deck for smoke or when the fire is confined to the store's content.

3. ***Trench cuts.*** Cutting a roof trench opening is sometimes done to combat a strip mall fire. A trench cut is a two- or three-foot opening cut between fire walls or, if necessary, across the entire roof to stop horizontal fire spread. A trench cut is used when fire is already spreading over a common roof space.

A trench cut is not a substitute for cutting a vent opening directly over a fire in a roof space. Cutting a roof vent over a fire will prevent horizontal fire spread by releasing heat and fire vertically. A roof vent cut should always be made before a trench cut. If a roof vent cut is successful, a trench cut will not be needed.

Cutting a trench takes time and a large number of personnel, so if you cut a roof trench opening, start several stores away from the fire. Furthermore, before you cut the trench, you should have hose line positioned below and on the roof, to stop the fire spread. At most trench cut operations, the hose lines stop the fire, not the trench cut.

Hose Line Strategy

The first hose line is stretched into the fire store. A primary search is conducted. Even if the store is locked, there could be night workers in the store. Retail clothing stores have night employees arranging clothes, and in some restaurants, families illegally sleep in back rooms. Next, an incident commander must determine in which direction the fire will spread and protect the adjoining store with hose lines.

After the store where the fire originated has been identified and a line has been stretched to extinguish the flames, the exposure stores on both sides must be protected with hose lines; the ceilings must be opened up, and flames must be prevented from spreading over the partition walls. The question is, which one of the adjoining stores should be protected first? If the incident commander does not answer this question correctly, the fire could spread throughout the common roof space, and all of the stores may be lost. In most instances, fire spread is determined by the direction in which the smoke is spreading. Smoke will flow in the direction the wind blows. The direction in which wind pushes smoke outside the stores is also the direction in which wind will push heat and flame inside the common roof space over the row of stores. The direction of fire spread determines which exposure store to protect with hose lines.

After the fire store, the next store to be protected is the one in the path of smoke spread (downwind). After the fire store and the adjoining downwind store have been protected, the upwind store should then be protected with a hose line. Firefighters with hose lines in both adjoining stores must pull open the ceilings with pike poles all along the partition wall separating it from the fire store. After the ceiling has been opened, direct the hose stream at any fire coming across the common roof space above the partition wall.

The overall hose line strategy may be summarized as follows:

- The first line in the store is to protect life.
- The second line in the downwind store is to stop fire extension.
- The third line in the upwind store is to confine the fire.

Explosions

Explosions occur in burning strip stores more frequently than in burning residential buildings. Explosive content is often found in store occupancies. Stores contain explosive material such as flammable liquids, paints, and propane gas. When burning, the synthetic contents of fabric store occupancies can create explosive gases. Also, a flammable liquid is usually the weapon of choice of an arsonist. Arson-for-profit fires frequently occur in stores during a recession. Also, a backdraft smoke explosion can occur when the store is tightly sealed up.

The following strategies will reduce the chance of an explosion:

- Vent the skylight and scuttle covers immediately. This may dissipate any explosive mixture building up in the store from the fire.
- Next, if there are windows or doors at the rear, these can be vented when the attack hose team starts advancing from the front of the store.
- At the front of the store, when beginning to enter the burning store and when the amount of fire visible through the plate glass windows indicates a potential explosion, the following defensive procedures should be taken before forcible-entry operations are started:
  - Position the hose line to the side of the store, away from a possible blast coming out of the store. This is a flanking position.
  - Charge the hose line with water and ensure that all firefighters are wearing protective equipment and face masks and are away from the front of the store, protected from flying glass and an explosive force.
  - Direct a firefighter standing to the side of the store window to use a pike pole to break the store windows.
  - Break the top half of the window first, then the lower half.
  - Open up the hose line and direct it into the store from a flanking position initially.
  - Let the smoke gases and flames vent out the front and then make your advance. The hose stream may stop any explosion by breaking up an explosive atmosphere.

There is a general rule in the fire service: Do not direct a hose stream at smoke; direct the hose stream at fire. This rule is true except when there is the danger that smoke and gases may explode and you cannot vent. When there is a danger of explosion, firefighters may direct the hose stream into smoke and stand at a safe flanking position. This hose stream directed into smoke may break up any explosive atmosphere. This is called quenching an explosion, and it is used only as a last resort.

To protect against explosions in a strip mall, the rule becomes venting—flanking—quenching. Vent the skylight, take a flanking position at the front of the store when forcing entry, and after opening the front entrance, direct the hose stream into the superheated gases to quench any explosive heat and fire gases.

Masonry Fire Walls

During the early stage of a strip mall fire, the incident commander must determine if there are any masonry fire walls (sometimes called party walls) separating the stores. The best chance to stop a fire from spreading in a common roof space may be at the fire wall. The incident commander should obtain this information when requesting a size-up from a firefighter operating on the roof of the burning row of stores. It is difficult to determine a fire wall's location in a row of stores from the command post, in the street. A fire wall's exact location can be best determined from the roof position by locating the parapet wall portion that rises up through the roof.

At a rapidly spreading fire, the stores separated by fire walls are where the fire chief may want to make a defensive hose line stand. The chances of stopping fire are best at this location. Hose lines may be sent to the roof and positioned behind the fire wall to stop the flames burning along the roof. When making a stand behind a fire wall on a roof, hose lines should also be sent into the store below, to stop flames that may seep out poke-through holes in the fire wall below the roofline. Firefighters in the store should pull the ceiling down near the fire wall and determine whether there are any poke-through holes or openings in the wall through which fire may spread.

At many fires, firefighters on the roof are attempting to make a fire stop with hose lines while the fire spreads through the wall beneath them. This is very poor firefighting. Always expect the unexpected. When making a stand behind a fire wall where fire is spreading in a common roof space, always check above the ceiling for poke-through holes used for air-conditioning ducts, electric wire, or piping through which fire may spread. Don't trust a fire wall at a strip store fire.

Collapse Dangers

A suspended ceiling in a store is a collapse danger. When fire spreads above a suspended ceiling and destroys the hanger straps holding the suspended ceiling, the entire ceiling and heavy framework can collapse in one section. Several hundred pounds of ceiling will then crush firefighters searching or advancing a hose line.

To prevent a ceiling collapse at a store fire, first extinguish the content fire before it spreads to the ceiling. Next, use a pike pole and check the ceiling space for fire; realize that there may be several dropped ceilings, so pull each one until you get to the underside of the roof. If there is fire above the ceiling, attempt to extinguish the fire, but realize that the weight of water from a hose stream can overload a ceiling and cause it to collapse. When fire involves the space above several dropped ceilings and cannot be controlled, withdraw firefighters from the store and protect exposures.

A parapet wall built over the front of a one-story strip mall is a collapse danger. A parapet is the portion of an exterior front wall that continues above the roof level. A steel beam spans the large windows and supports the parapet wall above. A small shock during a fire can topple a parapet down upon a sidewalk. An explosion, the impact of a master stream, or an aerial ladder can provide the shock that causes a parapet wall collapse. If during a fire the steel beam designed to support a parapet is heated to 1,100°F and starts to expand, warp, twist, or sag, it can cause a parapet wall to topple off its foundation.

A cornice is a decorative horizontal overhang, projecting outward along the top wall of a strip mall. A cornice is sometimes called an eyebrow. Whereas a parapet wall is the portion of an exterior wall extending above the roof, a cornice is the portion of the roof extending outward beyond an exterior wall. A cornice is also a collapse danger. A cornice is a cantilever structure—that is, it is supported at one end. A cornice may be constructed of wood or combustible plastic, and it may have a wood framework inside and/or wood shingles outside. A fire officer should also be concerned about horizontal fire spread from one end of a building to the other via a cornice.

Flames blowing out of a window of a strip mall store will spread to the cornice. Flames will then spread along the underside of the cornice or inside its hollow framework, possibly to adjoining stores. As the spreading flames destroy a cornice's supports, it can fall away from the facade. Also, when a cornice has been weakened by fire, it can collapse owing to a sudden impact of a ladder or if it is struck by a powerful master stream. If a parapet or cornice collapses, it will bring a wave of death and destruction crashing down upon firefighters operating in the doorways of a strip mall. Firefighters operating at one end of a building can be crushed under a falling cornice that starts to collapse at the other end.

When a strip mall has a parapet or cornice that is in danger of collapse, the incident commander should establish a collapse danger zone. Firefighters should not enter the collapse danger zone. A minimum collapse danger zone should be a distance from the front wall of the strip mall equal to the height of the front wall.

Exterior Fire Spread

The roof of a row of stores is a collapse danger, and in ordinary and wood frame construction, it is also the main fuel load. In some buildings, the roof is the only combustible portion. Starting from the top of a roof and working down, you have the combustible asphalt tar roof covering, the wood roof deck, a raised roof framework, the wood roof beams, and wood furring strips.

If the flames spread from the contents of one store and involve the roof structure, there will be a tremendous increase in fire. On a windy night, burning embers—called flying brands or flying embers—lifted by wind and heated convection currents can be blown great distances up into the sky and downwind. Flying brands may look like millions of harmless small sparks flying hundreds of feet into the air. Nevertheless, they are not: Rather, they are actually large red-hot, glowing pieces of wood. Wherever they land, they can start exposure fires. Roof fires, backyard grass fires, and car fires a mile away can be started by even one flying brand.

When fire burns through the roof of an ordinary-constructed or wood frame strip mall and flying brands start blowing through the air, ask the communications center to send an additional fire company to conduct a brand patrol. This company should size up the direction and distance the flying brands are being blown by the wind, follow their path downwind, and search the area for small fires. The brand patrol company will know it is in the right location when firefighters see charred and blackened pieces of wood on the ground. Also, check with the communications center for fires reported in the surrounding area.

Protecting Exposures

When considering which nearby exposed buildings to protect from fire spread, the incident commander should consider the following factors:

- ***Unseen exposures.*** First, realize that there are four exposure sides, and you may not be able to see one of the exposure sides—usually exposure C (or exposure 3), at the rear of the fire—due to smoke, darkness, or the height of the burning building. Next, if there is no firefighter on the roof to give a size-up of the surroundings, send someone to make a quick 360° survey.

- ***Proximity.*** Now, determine which adjoining structure is closest to the burning stores and determine which one is in the downwind path. If and when the fire becomes large and spreads through the roof, wind will eventually spread smoke, flame, flying brands, and convection currents of heat to this downwind (or leeward) side of the fire building. Order a protective hose line be sent to this location.

- ***Height.*** Next, consider which surrounding structure is the highest. This higher structure should be protected after the downwind one. The taller building is usually a high-value structure. Send a protection hose to this location. Not only will several hose lines operated from an exposure several stories high protect it from fire spread, but these hose lines can also be effectively directed onto the lower, one-story burning row of stores. If the convection currents of heat and fire are rising straight upward and there is no downwind exposure, then the highest adjoining building becomes the most serious exposure. There are no strict rules about protecting exposures. Order firefighters to stretch hose lines to whichever exposure you decide is the most threatened.

- ***Resources.*** At a defensive operation where resources are limited and fire is spreading rapidly in a common roof space, to get firefighters positioned ahead of the flames, one or two partially burning stores may have to be conceded. This could be required at night when a residence is threatened and the stores are unoccupied or in the daytime when the stores have been searched and evacuated.

The firefighting strategy to stop fire at a strip mall can be summarized in four steps:

1. Protect life.
2. Prevent extension of fire.
3. Confine the blaze on all sides.
4. Extinguish the fire.

For example, if the fire is beyond control of the companies on arrival, the first line is sent to the fire store to protect life, the second hose may be positioned into the exposed store on the downwind side, and the fire extension may be stopped after pulling the ceiling. The third hose line would then be positioned into the exposed store on the upwind side of the fire store, and another hose line might possibly be positioned to the rear, to confine the blaze. After the fire has been confined on all sides, the firefighting hose streams are switched to extinguishment in the store of fire origin. However, at a smaller fire in the same store, the first line would be sent into the store to extinguish the fire. The action of this first attack hose team, if successful, would simultaneously complete all of the aforementioned steps.

Strategy Summary

First attack hose line

The destination of the first attack hose line is the store of fire origin. A first attack hose line extinguishes 95% of all fires. After the fire has been extinguished, the ceilings are pulled to determine whether the fire has spread to the common roof space. The common roof space is a concealed space above the ceiling and below the roof. The common roof space may extend over the entire store in the building. If fire enters this concealed space, flames may spread through the common roof space and destroy all the stores.

Second attack hose line

The second hose line is stretched to the store on the downwind side of the fire store. Normally, in a multistory building, the second line is stretched to back up the first line, except if there is a danger of an exposure fire spreading. The downwind store in a row of stores is a serious exposure danger. The officer in charge of the second hose line in the downwind store should have firefighters obtain pike poles and pull down the ceiling along the partition wall separating the exposure store from the store of fire origin. After the ceiling has been pulled, the hose line should be used to stop fire from spreading to the downwind exposure across the partition wall. This line is stretched to stop fire spread. As soon as possible, notify the officer in command if the hose stream will be able to contain the fire or if the fire will spread beyond the downwind store. This information will be of great assistance in developing the firefighting strategy.

A third line should be stretched into the upwind store. Even if there is no indication of fire, this hose should be stretched here, the ceiling should be pulled, and the common roof space should be examined for fire spread. This line will confine the fire. Notify the incident commander as to whether the fire is spreading or contained.

Portable ladder

A portable ladder should be raised to the roof of a strip mall. The ladder is positioned in front of an adjoining store, away from the fire and smoke. The ladder should be positioned on the upwind side of the fire, as shown in figure 5–4. The placement of the ladder upwind of the fire will ensure that the smoke and flame from the spreading fire will not obscure or cut off escape by firefighters on the roof. The extension ladder tip should be raised several feet above the parapet wall so it will be visible to firefighters on the roof.

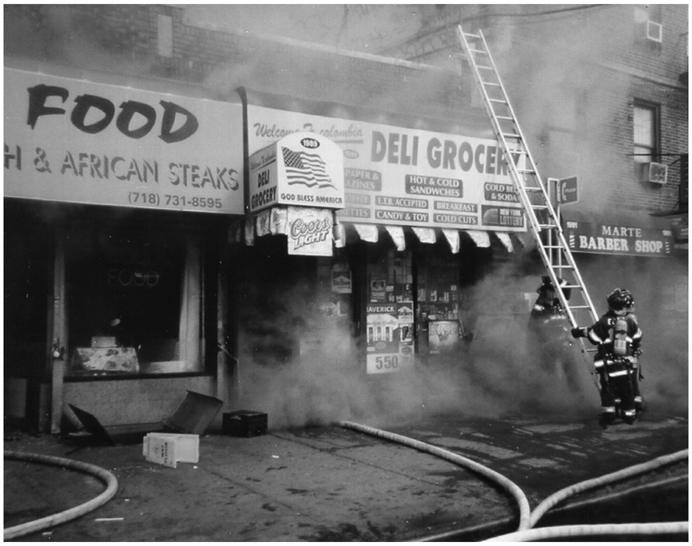


Fig. 5–4. Portable ladder positioned on the upwind side of the fire.

Primary venting

Primary venting at a strip mall fire comprises the skylights and scuttle covers that serve the store of fire origin. Firefighters on the roof should immediately vent all skylights and scuttle covers that serve the burning store. This roof venting need not be coordinated with the advance of the hose line.

Venting of skylights and scuttle openings will reduce the effects a flashover or backdraft explosion. Roof openings will also serve as vents to the hose team advancing the hose line. Steam and smoke pushed ahead of the advancing hose team will be released through these roof vents. After the roof has been vented, the store should be vented at the rear, opposite from where the hose team is advancing the line. The front window glass should be vented when the hose attack team starts to move into the store and extinguish the fire.

When fire is discovered in the roof space, the roof deck should be cut. Do not cut the roof when only smoke is detected in the roof; however, when it appears that the fire will not be extinguished, the roof deck should be cut in anticipation of fire spread to the common roof space. An opening should be cut in the roof to vent flames and heat out of the common roof space before the fire starts to spread horizontally over the adjoining stores.

If the fire in the roof space cannot be extinguished, a trench cut is the last resort of venting. Several stores downwind of the spreading fire, a vent strip three feet wide should be cut across the roof. Before the roof trench is cut, hose lines should be positioned above and below, in the store. The hose lines should stop the flames from spreading across the strip vent.

Aerial ladder position

An aerial ladder should be placed wherever the possibility exists that a master stream will be needed. In general, the master steam will be used on the downwind side of the strip store. If needed, another aerial ladder for master stream use should be positioned on the upwind side. If the entire store becomes involved in fire, four aerial master streams may be required.

Primary life hazard

During a daytime fire, the life hazard in a strip mall may be great. However, the presence of life hazard at a strip store is always a possibility, even at night. Illegal occupants may sleep inside restaurants. Night workers fold clothes and clean in retail stores. Furthermore, firefighters are always the primary life hazard in a commercial store fire.

Interior fire spread

Concealed spaces are the most common avenue of fire spread in a strip mall. Partition walls and suspended ceilings are concealed spaces that must be checked for fire spread. The most important concealed space is the common roof space. The strategy is to prevent fire from reaching this common roof space. If the fire reaches the common roof space and spreads, you may lose all the stores in the row. During the early stages of a fire in a store, always consider the possibility that the fire may be spreading up from the cellar; as soon as possible, check to see if fire is in the cellar. If a cellar fire goes undetected, the floors may collapse.

Exterior fire spread

The fire in a strip mall store may spread to adjoining stores through several other avenues. Signs on the front of the building stores and decorative cornices extending across the storefronts may have concealed spaces behind them that can spread fire. When the roof of an ordinary-construction store becomes fully involved, the convection currents and the flame front can be 50 feet high. Airborne embers can rise with the convection currents. Also, any high buildings adjoining or near the strip mall are an exposure problem. When the strip mall adjoins a higher building, a hose line should be stretched into the higher building, and an aerial master stream should be positioned to the stop fire from spreading from the burning stores to the higher building by radiation waves, convection currents, or flying brands.

Collapse hazard

The deadliest collapse danger in a strip mall is the parapet wall. The parapet wall is the freestanding wall at the front of the building that extends above the roofline. A decorative cornice, creating a cantilevered load, may be attached to the parapet wall. Marquees, canopies, and signs connected to the parapet wall present additional dangers. These attachments on the front wall of a row of stores are deadly collapse dangers.

Inside the store, the ceiling is a collapse danger. Firefighters have been trapped and killed by suspended ceilings collapsing inside strip stores when advancing hose lines and pulling ceilings. There may be several ceilings in a store—one ceiling suspended below another ceiling. During a fire in a store, two and three suspended ceilings create a dangerous condition. Overloaded ceilings can collapse and block a firefighter's escape. Fire can destroy the ceiling hanger strips, and water from hose streams can be absorbed by the ceiling insulation and overload the ceiling. When checking ceilings for fire spread, every suspended ceiling must be opened up and checked for fire spread.

Worst-case scenarios

A parapet wall collapse is the greatest danger. If the parapet front wall collapses, it can crush firefighters operating hose lines on the sidewalk. Another danger is the ceiling. The ceiling may collapse on firefighters searching inside a store. Fire in the ceiling and roof space will burn the ceiling supports.

Another worst-case scenario is if the fire spreads throughout all stores and then extends to adjoining buildings. Convection currents of flame shooting 50 feet over the roof may spread flames and smoke to adjoining higher buildings. Airborne burning embers can also spread fire downwind up to a mile away.

6 ROW HOUSE FIRES

In the 1960s and '70s, the FDNY was having difficulty stopping fire in row houses and high-rise buildings. Therefore, in the 1970s, the New York City fire chief ordered that full-scale test fires be conducted to scientifically document how fire spreads in these structures and to determine more effective methods of firefighting in row houses. The FDNY and the Brooklyn Polytechnic Institute (now New York Polytechnic) teamed up in conducting test fires in wood frame row houses, and as a new battalion chief, I was assigned as coordinator of the tests. Twenty-four full-scale, controlled fires were set. Fire spread and methods of firefighting were evaluated. The full-scale fire tests, using four vacant buildings in the Bushwick section of Brooklyn, were conducted to determine (1) the best firefighting strategy to extinguish fire in row houses, and (2) the fire spread problems associated with this type of attached dwelling.

In New York City, row houses have a construction defect that makes firefighting difficult. It is the common roof space (fig. 6–1). A row of 8–10 buildings may have a common roof space extending over the top-floor ceilings of all the dwellings in the block. If fire enters this roof space, it can spread over the tops of all the buildings in this concealed space. There are generally no fire divisions separating the common roof space that could stop fire spread, and even if there are, the fire divisions usually have

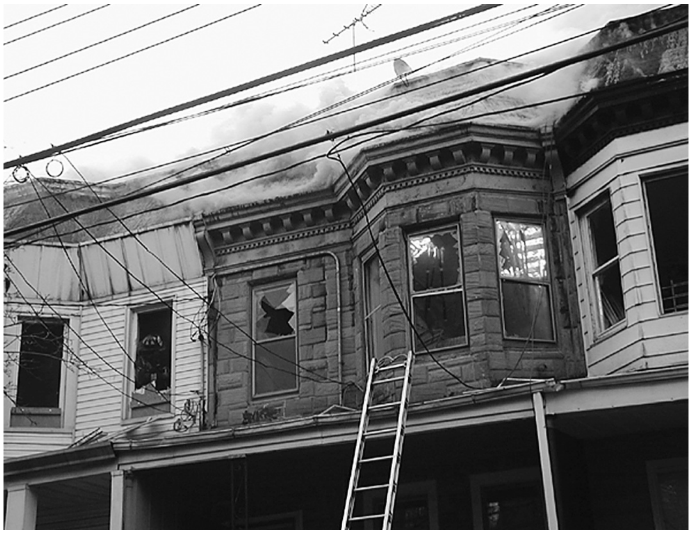


Fig. 6–1. The row house has a construction defect, the common roof space.

holes and defects that allow fire to spread from building to building. In actuality, porous fire divisions are worse than having no fire division. Fire divisions that have holes for crawl through and missing bricks give an incident commander a false sense of security. Years ago, the importance of fire divisions separating the common roof space of each building was not known. This type of old row house with the common roof space can be still found throughout the nation. In fact, some modern town houses and garden-type apartments have this same construction defect.

The following sections outline firefighting strategies for older-type row houses that also apply to modern town houses, condominiums, and garden-type apartments.

Firefighting Strategy

The firefighting strategy for stopping fire spread in row houses is the same as for stopping fire spread in strip malls. Firefighters must stop the vertical spread before fire reaches the common roof space. If the flames spread into the common roof space, the strategy becomes to stop the fire from spreading to the adjoining row houses. With a two- or three-story row house, you have more time before flames reach the common roof space than you have with a one-story strip mall. Sometimes you have two or three floors to stop the fire before fire reaches above the top floor and the common roof space.

Locate the fire

Historically, fires in row houses have spread because of misidentification of the floor or the adjoining building, designating the leading edge of a fire spreading up to the common roof space. For example, if a firefighter tells the incident commander that there is fire on the first floor and the fire is actually on the second floor, then the hose line will be stretched to an incorrect floor, below the fire; consequently, the flames may spread up to the common roof space, and the incident commander's strategy will fail.

To properly identify the location of a fire, officers must know what to call the lowest level of a multistory building. The lowest floor is called the first floor, not the ground floor. Some buildings are mislabeled ground floor, then first floor, second floor, and so on. There is no such fire department term as ground floor. It is the first floor.

Another instance when the floor of the fire is not accurately determined is when you have to step down several feet below the street level to a doorway located beneath a front entrance stoop of a row house. This level is considered a basement, rather than a cellar, and a basement is considered by the building code and the fire service to be the first floor. A basement has over one-half of its floor level above street level. A cellar, by contrast, has more than one-half of its floor level belowground and is not considered a floor level when computing the height of the building. A row house with a basement and two levels above is considered a three-story building during a firefighting size-up, not a two-story building.

In some cases, residents refer to the second floor of a row house that has a large front entrance stairway leading to the second floor as a parlor floor. Again, there is no such thing as a parlor floor in fire ground communications. If you stretch a hose up the front steps to attack a fire, tell the incident commander that you have fire on the second floor of the row house, not the parlor floor.

Position the hose line

Row houses can be one, two, or three stories high. The first hose line is stretched to the point of fire origin to extinguish the blaze. The hose line is usually taken into the front entrance to the fire apartment. The second hose line also is stretched to the front entrance to back up the first attack hose team. However, if the first attack hose line is extinguishing the fire without any problems, the second line may be redirected to the floor above the main fire to cut off vertical fire spread. After you stretch the first line to the fire, the second line is stretched to cut off vertical fire spread, to prevent it from reaching the common roof space.

If the flames are not cut off by the second attack hose team and they reach the common roof space, the next strategy is to send a hose team with the third hose line to the top floor of the adjoining building where the fire is spreading. This is usually the downwind adjoining dwelling. Top-floor ceilings are opened up in the adjoining building, and the hose stream is directed into the common roof space to cut off fire spread. At a serious fire in a row house, the incident commander should be proactive and not wait for the size-up report to determine whether fire has spread to the common roof space. The incident commander can order the third hose line be stretched to the top floor of the exposed adjoining building as soon as firefighters are available.

One-story dwelling. If the row house is one story high, the second hose line backs up the first hose team. However, if fire has reached the common roof space, the incident commander may order the second hose line be stretched to the adjoining exposed (usually downwind) dwelling and the ceiling be opened up in the exposure and fire extinguished.

Two-story dwelling. If the fire is on the first floor and it is reported that flames are spreading up through concealed spaces, the incident commander may order the second line be stretched to the floor above in the dwelling, to cut off vertical fire. The purpose of stretching the second line is prevention of fire extension to the common roof space. However, if the fire is on the top floor of a multistory row house and it is obvious that flames have already reached the common roof space, the incident commander may order the second line be stretched to the top floor of the adjoining downwind dwelling. This line is used to prevent fire extension. The top-floor ceilings are opened in the exposure, and the fire spread is stopped with the hose stream. Another line is stretched to the top floor of the upwind dwelling to confine the fire if the first attack hose team cannot extinguish the main fire. The incident commander should inform the first attack hose team whenever there is no backup hose coming, and defensive operations may be the recommended. The incident commander may have another company stretch a backup hose line.

Three-story dwelling. If the fire is on the first floor of a row of three-story dwellings and is spreading up concealed spaces heading to the common roof space, the first line is stretched to the first floor to attack the fire, the second line goes to the floor above, and the third line goes to the top (third) floor. The strategy is to stop the vertical fire spread before it reaches the common roof space. However, if the fire is on the top floor of a three-story dwelling, the first line is stretched to the top floor to extinguish the main fire, and the second line is stretched to the top floor of the adjoining downwind dwelling to stop fire extension. The third line may be sent to the top floor of the other exposure, to confine the fire.

Fire Spread Problems Associated with Row Houses

Stopping vertical fire spread in a concealed space of a row house is the key to a successful firefighting operation. Check the concealed space for the presence of fire or heat. Use a thermal-imaging camera if available. If not, look for heat discoloring or feel the floor or wall surface with your bare hand. If it is too hot to touch, open up the hottest area with forcible-entry tools. A hose line should be ready where the leading edge of the concealed fire spread is suspected. The firefighting procedure for opening up floors, walls, and ceiling to stop vertical fire spread in concealed spaces is as follows:

- If fire is discovered in the floor, open the wall where the floor beams meet the wall and extinguish the fire there.
- If you discover fire spreading in the wall, open the ceiling where the wall studs meet the ceiling and extinguish the fire there.
- If you discover fire in the ceiling, go to the floor above and open up the floor directly above the fire area; then, bring in a hose line and extinguish the fire there. The objective is to cut off vertical fire spread before it reaches the common roof space.

If flames reach the roof space, the fire may spread to several adjoining buildings by way of the common roof space (fig. 6–2). Don't let fire get to this common roof space location. As a further warning, if the row house is of lightweight wood truss construction, realize that you cannot stop fire spread once it reaches the concealed spaces of the truss. For example, if the fire is in the concealed floor space, in lightweight wood truss construction, flames will spread between the floor truss beams and travel to the wall; however, unlike conventional solid beam floor construction, fire also spreads in a perpendicular manner through the truss web members. Fire spread is 100% faster in the concealed spaces of a lightweight truss–constructed building, and the collapse of the burning floors and roof occurs much more quickly. In a building of lightweight wood truss construction, when flames are spreading uncontrollably in the

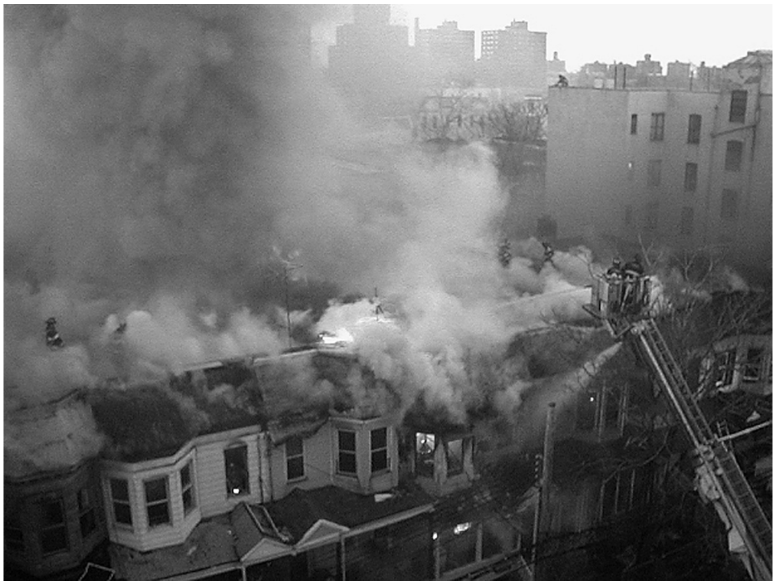


Fig. 6–2. This fire is spreading to adjoining buildings via the common roof space.

concealed spaces, the strategy employed should be to get the people out and protect the exposed row houses with hose lines.

Light shafts open at top

In some row houses, there are shafts that were designed with the intent of bringing sunlight into rooms of the apartments. These shafts have windows built into the walls, allowing rapid vertical fire spread from floor to floor. Also, when fire enters the shaft, it may spread vertically, into the common roof space at the top of the shaft through the eaves (the wood framework around the top opening of the shaft). Fire must not be allowed to enter the shaft, and if fire already is in the shaft on arrival, it must be extinguished quickly.

These two-foot-by-two-foot interior light shafts may be enclosed by four plaster or wood walls. The light shafts can be located in the interior of the building, and they extend from the basement to the roof. In some cases, the shafts start at the first- or second-floor level and are called blind shafts. In some row houses, the shafts are enclosed by only three walls, creating a narrow alley between buildings that is open at the front or rear of the structure; such shafts extend from the street level to the roof. Interior rooms have windows opening onto these shafts. While designed to bring sunlight and air into the interior rooms of the row houses, these shafts can also bring flames into the interior rooms.

Fire may also spread into the common roof space from a light shaft. There is usually a rotting piece of wood framework at the eaves around the top of the shaft, with plenty of spaces through which flame may spread from the shaft into the roof space. A firefighter working on the roof must notify the incident commander whenever fire is discovered in a shaft.

Several of the scientific full-scale fire tests conducted by the FDNY and the Brooklyn Polytechnic Institute in the 1970s were shaft fires. An important finding was that fire spreading up in the shaft extends into the top-floor windows first, even before the first- and second-floor windows. As the flames spread upward, they feed on the combustible shaft surface walls and are hottest at the upper portion of the shaft. This information confirms the strategy of stretching the second line, at an apartment fire that spreads into the light shaft, to the top floor and then stretching any additional lines to the intermediate floors as fire conditions dictate.

Note that this strategy for cutting off vertical fire spread in a shaft fire is different than the strategy used for cutting off fire spread in concealed spaces. At a fire spreading in concealed spaces, the second hose line is stretched to the floor above, not the top floor. A fire in a concealed space does not spread as rapidly as a fire in an air shaft.

A common strategy mistake made in combating a fire on the first floor of a three-story row house, when the fire has already entered the shaft, is to stretch the first line to the apartment that is on fire and stretch the second line to the second floor and then to the third floor, in that order. After the first line is stretched and it is confirmed that fire has entered the shaft, it is good strategy to stretch the second line to the top floor to cut off fire spread into the top floor through the window from the shaft or into the common roof space. At the top floor, pull the ceiling with a pike pole and extinguish the fire. The strategy for a shaft fire is to stop flames from spreading into the common roof space. Remember, the strategy is to prevent vertical fire spread and then prevent horizontal fire in a row house.

Venting row house fires

The primary venting at a row house includes both the windows of the fire apartment, and the roof skylights or scuttle covers at the top of the stairway. The windows are vented as the hose team advances on the apartment fire. This can be accomplished by firefighters operating from portable or aerial ladders. In some instances, there are rear fire escapes or balconies where firefighters can stand to coordinate window venting with the hose line advance.

To stop fire from banking down on the top floor of a burning row house and spreading to the top-floor apartments or the common roof space, primary ventilation includes removing the roof skylights or scuttle covers at the top of the stairs. These top-of-the-stair vents must immediately be opened to expel heat and smoke from the stair enclosure. When the skylight or scuttle cover at the top of the stairs is opened, heat and smoke coming out of any apartment on the lower floors will quickly vent out the roof opening. This venting will delay fire spread to the floor and even to the common roof space (fig. 6–3).

The roof stairway skylights and roof scuttle covers must be vented immediately. Do not wait for the hose line operation to vent this opening over the stairs. This action is so important that fire companies that respond in row house districts usually have one firefighter assigned exclusively to this duty. The firefighter goes immediately to the roof and opens the skylights and scuttle covers over the stairway in the row house. The first-arriving aerial ladder, if not required for rescue, is positioned on the roof, upwind from the fire, and a firefighter climbs the ladder to vent the roof over the stairs. This firefighter does not wait for permission to vent this scuttle; it is done immediately.

This roof venting is done even if the fire is on the first floor. When firefighters open the door to attack the fire on the first floor with the hose line, smoke and heat will come out of the apartment, flow over their heads and travel up the stairs. If the scuttle is not open, the smoke will build up on the top floor and mushroom out into the apartments and kill people on the top floor and spread to the common roof space. Years ago, before the importance of roof venting was known, firefighters would extinguish fires on the lower floor and find people dead on the top floor from smoke and heat and fire inside the common roof space. Roof venting saves lives.

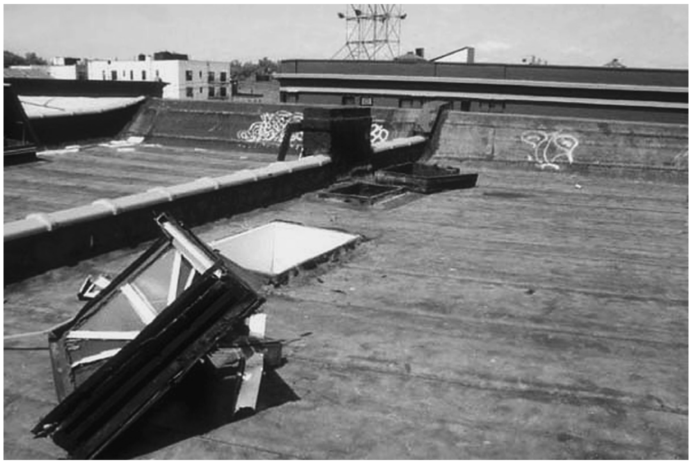


Fig. 6–3. The roof scuttle cover must be vented immediately.

Sliding-door concealed spaces

Another avenue of concealed vertical fire spread is provided by sliding (pocket) doors. In some older row houses, rooms are separated by sliding doors. A doorway opening containing a sliding door is very different from a doorway containing normal doors. A normal doorway, containing a pull-open door, has the inherent fire-stopping ability of the opening between rooms—in particular, the header beam over the doorway opening and the trimmer beams down the side of the opening. (A header beam is the beam at the top of the opening. Trimmer beams are the beams on each side of the doorway.) A doorway containing a sliding door has a large concealed space in the wall, in a pocket that contains the door when open; these may be paired, such that there are concealed spaces on both sides of the doorway.

Flames may spread to concealed spaces that contain sliding doors and then travel upward to the floor above or to the common roof space if the top floor is the fire floor. If the sliding doors are located on every floor in the same location, fire may spread in the concealed space of the sliding doors from the first floor up to the common roof space. The pockets for the doors may create a vertical channel in the walls leading up to the roof space. Make sure you check this concealed space soon after a fire is extinguished.

When fire gets into the common roof space, it spreads unobstructed throughout this large concealed space. It can completely involve the roof, and sometimes flames spread over several adjoining buildings through this common roof space. If the fire does reach the roof space, the best strategy to prevent horizontal fire spread is to cut a roof vent over the fire (fig. 6–4). Cut the roof deck over the fire; this action will allow convection currents of flame and heat to rise out the roof space instead of traveling horizontally. The roof vent is designed to stop horizontal fire spread in the common roof space.

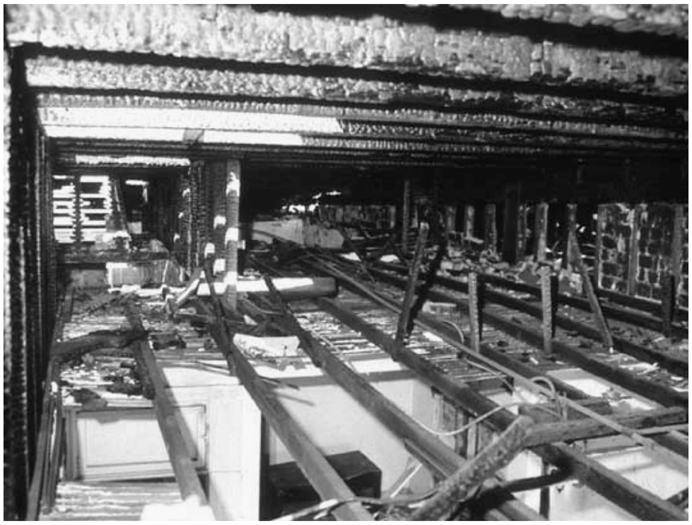


Fig. 6–4. Strategy is to prevent fire from spreading to the common roof space.

Horizontal fire spread

Fire divisions are required by law to separate some row houses. However, during a fire in a row house, the incident commander must always assume that there is no fire division between buildings or, if there is a fire division, that the fire division will not stop the fire, owing to poke-through holes in the plaster, missing bricks, cracks, or holes made by workers renovating the building.

If it is confirmed that fire has already entered a roof space before the roof can be vented, the incident commander must first determine which way the fire is spreading and, second, designate a *cutoff building*, where a fire company can take the time to stretch a hose line, pull the ceilings, and make a stand to cut off spreading flame. When fire enters a common roof space, fire will spread both ways, but faster in the downwind direction. For example, if the wind and smoke are flowing toward exposure B, a firefighter on the roof should assume that the fire in the common roof space will spread in this direction. He or she might then have to go two buildings downwind from the fire building to find the outer edge of the common roof space fire spread and designate a cutoff building. When the outer edge of the fire spread in the row of dwellings has been determined, a hose line should be called for to extinguish the blaze. This decision must be made with consideration for the time it takes for the hose team to get the hose and nozzle into the top-floor position.

Brick nogging. Brick nogging is a construction term describing an ineffective brick partition wall in the roof space, between the wood studding separating buildings constructed in a row. It should not be depended on to stop horizontal fire spread. This partition wall of brick nogging was built to separate the dwellings. A brick-nogging wall, from the cellar to the roof, provides soundproofing only, not fire resistance; some fire chiefs erroneously consider it as fire-stopping.

The problem with brick nogging is that the bricks are not cemented together well. They fall apart or are knocked out of position, leaving a small space through which fire can spread. Also, two-foot-by-two-foot crawl spaces are sometimes built into the nogging wall as access openings. This can occasionally be found in the common roof space.

Brick nogging can never be relied on as a fire-stop. There may not be mortar between the brick, or there may be brick missing, or the brick nogging may not go to the underside of the roof. Check the common roof space for fire spread by pulling ceilings in adjoining buildings.

Cornices. A cornice is the decorative framework at the top of the front wall near the roof edge. A decorative cornice on a row of houses leaves a concealed space in which fire can spread horizontally. Flames coming out of a top-floor window may spread to the cornice. If the cornice is wood or combustible plastic reproduction, the fire spread along the cornice may be rapid and will have to be stopped immediately with an outside hose stream. If the cornice is metal, the fire spread will be concealed and much slower, confined to the interior wood framework of the cornice. Fire spread along a metal cornice can be addressed after the top-floor apartment fire has been extinguished, unless the cornice is made of wood; then, fire spread will be rapid.

In many instances, the smoke issuing from a cornice originates from a fire in the common roof space. Extinguish the fire in the roof space and the smoke will stop coming from the cornice. The interior concealed space of a cornice that extends the entire length of 5–10 buildings is required by law to be fire-stopped every 20 feet. However, this should not be expected.

To stop fire spread in a cornice, position an aerial platform or ladder with firefighters near the cornice. Then, firefighters on the ladder, using a hook or pry tool, can open the cornice and examine it for fire. If fire is burning in the cornice framework or the wood facade, a hose line can be borrowed from the top-floor apartment, and the fire can be extinguished by the firefighter operating from the ladder.

Combustible siding. The siding on row houses may be noncombustible brick, combustible wood siding, or combustible asphalt siding that looks like brick. A row of houses with a wood or asphalt exterior surface complicates the firefighting strategy. When a fire occurs in a row house, hose lines will have to be positioned inside the structure, as in any structural fire in ordinary construction, but a hose line will also have to be positioned outside the building, to stop exterior fire spread in the combustible siding. In addition to the interior hose lines, a booster line, hose line, deck pipe, or aerial master stream may have to be put in play to stop a fast-spreading fire along the exterior of the houses. The aerial ladder should be positioned downwind on the A or C side of the row houses to stop a siding fire. Fire may even spread up the exterior siding of the building, feeding on wood or asphalt, to the cornice and spread into the common roof space at the cornice or the eaves of the building.

Asphalt siding is actually shingles of a tarlike combustible petroleum product. When heated, asphalt shingle reverts to tar, and heated tar siding will cause an explosive fire spread. Also, flaming drops of liquid petroleum will rain down the side of the structure as the flames spread upward along the building exterior walls.

Fire Ground Designation

To accurately communicate to the command chief the location of a victim trapped at a front or rear window where a portable ladder is needed for a rescue, you must be able to describe over the portable radio where the victim is located in relation to the command post. Also, if you discover fire spreading from one building to a nearby structure and you call for the placement of a hose line to protect exposures, you must be able to inform the chief in charge of the exact position of fire spread. To do this, you must use a fire ground designation system.

Most fire departments use a fire ground designation system called sectors or exposures to define the area around a burning building. Terms such as exposures A, B, C, and D or sectors 1, 2, 3, and 4 are commonly used. The command post is located at exposure (or sector) A; this is the front of the fire building. From a bird's-eye view, starting at the command post and proceeding clockwise, exposure B is the left side of the fire building, exposure C is the rear of the fire building, and exposure (D) is the right side of the building.

Fire Building Designation

When fire spreads in a common roof space over several row houses, a building designation system is necessary to pinpoint a cutoff building, to state exactly where you are operating, and to relate accurately where the flames are spreading in the common roof space. A building designation system often used to describe fire in a row of dwellings is to add numbers to the letters of the exposures. For example, from the viewpoint of the command post, row houses located on the left side of the original fire building (where the fire started) are designated exposures B, B1, B2, B3, and so forth; row houses on the right side of the fire building are designated exposures D, D1, D2, D3, and so forth, proceeding away from the original fire building.

Defensive Firefighting

In rare situations, fire already involves all floors of a vacant one-, two-, or three-story row house on arrival. Here, no hose line is stretched into the fire building. The strategy may be to stretch the first line to the top floor of the adjoining downwind dwelling, the second line to the top floor of the adjoining upwind dwelling, and the third line to an aerial master stream. The aerial platform is positioned in front of the vacant building; if the building is fully involved and unattached, the first line could be ordered to supply an aerial master stream, and firefighters could be withdrawn from a collapse zone. When a fire occurs in a row of dwellings, the end building presents the most likely collapse danger. End buildings unsupported at one side may suffer a lean-over–type collapse.

Fires in old row houses are difficult to fight because the structures have major construction defects: concealed spaces, combustible exterior, air and light shafts, sliding door voids, decorative cornices, and a common roof space that extends over several dwellings. It is as if the row house was built to burn. Thus, the strategy employed is to stop vertical fire spread to the common roof space, and if that fails, the strategy becomes to stop fire from spreading to adjoining buildings through the common roof space (fig. 6–5).

Fire spread in a row of dwellings creates tremendous public relations problems for a fire department. The department's reputation suffers much more when several row house burn, compared to a fire destroying a large apartment house. There may be 25 families burned out of the apartment house, yet a row house fire that burns down the homes of five families will generate much more criticism of the local fire companies. For example, when the large apartment house burns, the media reports one building burned with no loss of life; the owner of the burned-out apartment building is usually an absentee landlord (i.e., does not live in the building), and large professional properties generally have fire insurance that covers most of the cost of repair and renovation.

By contrast, when a row of dwellings burns, the news reports fire spread to five dwellings. The five row houses are usually owner occupied, and angry home owners standing at the command post can not understand why the fire was not stopped; they want answers. The owners do not understand the construction defect of their row houses—the common roof space. Also, the home owner policy may not cover all the fire damage. Complaints to city hall often follow a serious fire in a group of row houses.

Today, we see the construction of a new type of row house that has many of the same defects—and thus are also built to burn. They are called town houses, garden-type apartments, or condominiums. They may have changed the name, but these dwellings have the same fire spread problems of the old row houses; moreover, they have the added problem of the lightweight wood truss, which provides 100% more rapid fire spread when a fire is in the concealed floor or ceiling space. There is a time-honored saying that also applies to the fire service: "Those who cannot remember the past are doomed to repeat it." Good luck!

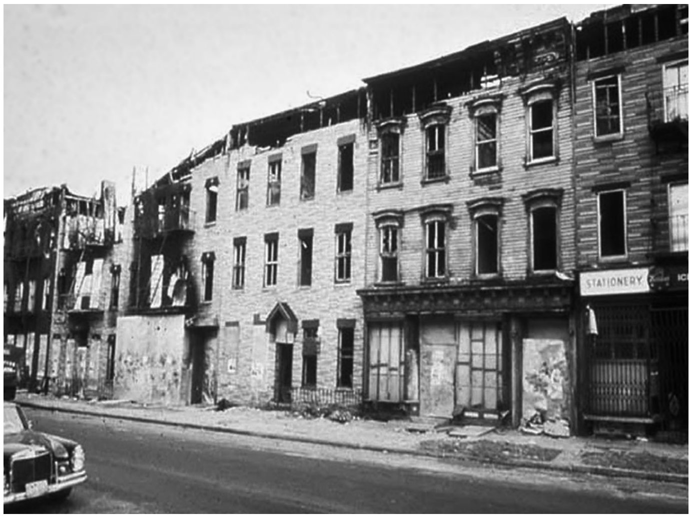


Fig. 6–5. Fire spread throughout the row house common roof space.

7

FIRES IN PLACES OF WORSHIP

From an incident commander's point of view, a burning church, synagogue, mosque, or temple is just another old structure built to burn and collapse. These buildings are usually poorly designed and dangerous structures that should be considered target hazards. Prefire plans should be prepared for a house of worship and should recommend a defensive outside attack with emphasis on protecting nearby exposures. A defensive firefighting strategy should consider the possibility of collapse of the steeple, the bell tower, the ceiling, the truss roof, and/or the side walls.

Preplanning

Prefire target hazard inspections should be conducted for every house of worship in your community. The impact of the loss of a place of worship by fire is great. Local religious buildings are often the most significant historical structures in town. As a fire chief, you do not want one to burn down.

A fire chief has the responsibility to inspect and advise the congregational leadership on how to make their building fire safe. The chief may be reluctant to give bad news about fire hazards to a religious leader, especially in a poor community; nevertheless, it must be done. The fire service, with the help of political leaders, has long overlooked the fire safety of religious buildings, and this deficiency is demonstrated when there is a fire. The building is a total loss.

A prefire inspection should start at the basement and work up to such areas as the bell tower, the steeple, the attic spaces (if there is an attic), and the choir loft. Locating access stairways to these out-of-the-way places is critical to firefighting. Many fires start in the basement, tower, steeple, or attic. Before the firefighting strategy is implemented, the fire must be located; that is, the first arriving firefighters cannot waste time looking for the stairways leading to these spaces. Even if a fire is quickly extinguished with an interior hose line attack by the first arriving firefighters, these concealed spaces must be checked for fire extension.

Most important, after any fire, firefighters must check the largest concealed space in a church—the attic. Again, firefighters cannot waste valuable time looking for the stairway leading up to the attic. In a place of worship, there are usually no signs indicating where the stairs to the attic or bell tower are. Hard-to-find small doors and spiral stairways are common in these buildings. A prefire inspection will usually reveal a hundred-year-old building that has undergone many renovations.

The walls and columns may look like stone but are usually stone imitations with plaster and wood lath. The large open area or small concealed spaces behind imitation stone walls, within hollow columns, or in the attic can allow fire to spread beyond the control of firefighters operating hose streams. In addition, the structure will contain many other occupancy hazards: overloaded inadequate electric wiring, open candle flames, interior wall and ceiling surfaces with dangerous flame spread ratings, ceilings so high that hose streams cannot reach the upper levels, electric and kerosene portable heaters, and last but not least, a major forcible-entry problem. If these buildings were not considered sacred, most would be shut down for violations of the fire and building codes. Furthermore, each of these structures would be ordered to install immediately a fully automatic extinguishing system throughout the entire building.

Problems Associated with Firefighting in a House of Worship

Case study 1: Access to the fire

A fire officer friend in a Pennsylvania fire department told me a story of a church fire. During a rainstorm with thunder and lighting, the first ladder arrived at an old town church that had a small fire in the roof eaves, evidently caused by a lightning strike. The chauffeur starting to raise the aerial ladder in the lightening storm was ordered not to raise it, owing to the danger of another lightening strike.

The firefighters ran up to the steps to the entrance and found the heavy wood timber doors locked. In the downpour, while the firefighters were trying to determine how and where to start forcible entry, a woman came running up the steps, holding a ring of keys. The firefighters opened the large doors and noticed a light whiff of smoke in the sanctuary. They spread out, trying to find the stairs leading up to the burning attic. No one could find the staircase, and the woman did not know this critical information. No one could locate the fire.

Suddenly, a priest ran in, shouting, “Follow me!” He showed them a small stone winding stairway leading up to the attic. A narrow wooden walkway extended across the entire length of the attic and was positioned over the top ridge peak of a gothic plaster ceiling.

A small portable extinguisher was carried up the winding stairs. The firefighters approached and quenched the small fire near the eaves by using the stream of the portable extinguisher. This small water source gave the firefighters precious time, before the fire started to increase in size, in which a hose line was stretched up the winding stairs. The fire was fully quenched by discharging a limited amount of water from the hose line, so as not to collapse the plaster ceiling.

Case study 2: Surface flame spread

While attending a service in the Saint Francis Church on 31st Street in Manhattan, I noticed that the stone mosaic figures depicted on the walls and ceiling looked very shiny and new as compared to my memory of them from previous years. The gold, red, and blue mosaic pieces were bright and glistening. After the service, I asked the chaplain, “Did they install new mosaic walls in the church?” He replied, “No, they just cleaned the entire inside of the building." Vapor given off from the burning of the candles 24 hours a day, seven days a week, for several decades, had left a film of wax on everything. This illustrates one reason why church fires are difficult to extinguish: if the ceiling is wood paneling supported by wood trusses, it will burn even faster when there is a wax coating on the surface.

Case study 3: Large open space

I was invited to inspect a historic, hundred-year-old Protestant church on New York City's Madison Avenue, at the request of a parishioner who was a friend of the FDNY. Homeless people slept in the vestibule every night. During the afternoon when we inspected the church, it was dark, and several homeless people were sleeping in the pews. You could hear them snoring.

The parishioner was concerned about a fire and asked what my firefighting strategy would be to fight a fire inside the famous old church . He did not want to remove the homeless people. I gave him the bad news. I said that all we could do would be to save either the roof or the stained-glass windows. In other words, we could let the roof burn and not break the stained-glass windows, or we could break the windows to vent the smoke and hopefully save the roof.

I advised him further that if he really wanted the church to last another hundred years, he should install smoke detectors connected to the central fire dispatcher and install automatic sprinklers throughout the building, including the attic, bell tower, and basement. I informed him that our hose streams have a reach of 50 feet and could not reach fire burning in the wood trusses, since the church ceiling was 60–75 feet high. I also told him that the large open floor area was so big that it could not be extinguished by firefighters with hose streams. If a fire started when the church was not occupied and was allowed to grow, we could not move in from the front door or the side door owing to the large amount of fire. One hose line can only extinguish about 2,500 square feet of fire.

Case study 4: Attic fires

Two Valley Stream, New York, firefighters were killed in a synagogue fire. After knocking down a fire in a small room next to the main altar, heat and flames were quickly reduced, and firefighters assumed the blaze was extinguished. However, unnoticed in the smoke, flames had spread up to the attic space through a small spiral staircase. In the attic, concealed by a recently installed ceiling, truss roof supports were burning. As firefighters were leaving to refill air masks, the ceiling and timber truss roof collapsed. The collapse and ensuing fire trapped several firefighters, killing two.

In a similar incident, Memphis firefighters knew they had fire in a church attic. A hose line was stretched into the building, and a portable ladder was placed near a side wall. The ceiling was being opened with pike poles to expose the fire in the attic. Without warning, the ceiling and lightweight trusses collapsed into the church, trapping several firefighters. Two firefighters were killed.

In Philadelphia, two firefighters were caught and trapped in a church fire. Smoke heat and the unusual layout of the interior of a large facility were contributing causes of the firefighters' deaths.

Case study 5: Bell tower collapse, Pittsburgh

After several hours of fighting a fully involved church fire, a safety inspection was started to assess overhauling dangers.

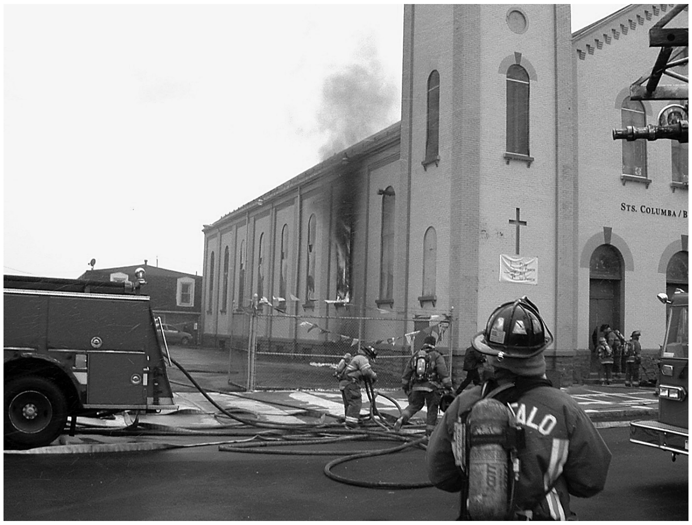


Fig. 7–1. The Ebenezer Baptist Church bell tower collapse killed two firefighters.

During the inspection, the back portion of the bell tower collapsed into the church, and portions of the tower collapsed outside (fig. 7–1). Two firefighters were killed, 29 were injured, and 9 had to be hospitalized.

Dangerous Parts of a Worship Building

When assessing a city or town's ability to withstand earthquakes, structural engineers analyze the stability of different parts of a building. They want to determine which parts of a building fail and which parts of a building withstand the ground shaking during an earthquake. Studies have found the most unstable structure in a community is a church tower and steeple. A tower has a wooden interior stairs or ladder, and several platforms support one or more heavy steeple bells suspended by ropes or cables. These towers and steeples are considered less stable and more likely to collapse first during an earthquake. Other unstable building parts are chimneys on rooftops, parapet walls over stores, nonbearing walls and bearing walls (a bearing wall is a wall that supports a weight other than its own weight), and floors of buildings.

Small-scale replicas of buildings are constructed in earthquake test laboratories, and scientists observe how they react to the ground-moving effects of an earthquake. The laboratory test starts with a minor ground shaking, and on each subsequent test, the strength of the earthquake gets stronger. As the platform moves and simulates a mild earthquake, the church steeples collapse first; next, a stronger quake causes the chimneys to crumble; then, with more shock, the freestanding parapet walls topple; finally, as the shaking increases to maximum, the test building's nonbearing walls cave in, the bearing walls collapse, and the roof and floors collapse with them. Scientists and engineers rate parts of a building as to their susceptibility to collapse during and after an earthquake. The church tower and steeple are among the most unstable and the first to fail. This lesson has relevance to the fire service: when an explosion or a partial collapse occurs during a fire, it shakes the structure too.

Aggressive Interior Attack

Despite the aforementioned dangers, firefighters remain optimistic. We must believe that we can succeed and extinguish any fire in a place of worship. This optimism is confirmed by the statistic that 95% of all fires are extinguished by the first attack hose line. However, the can-do attitude, together

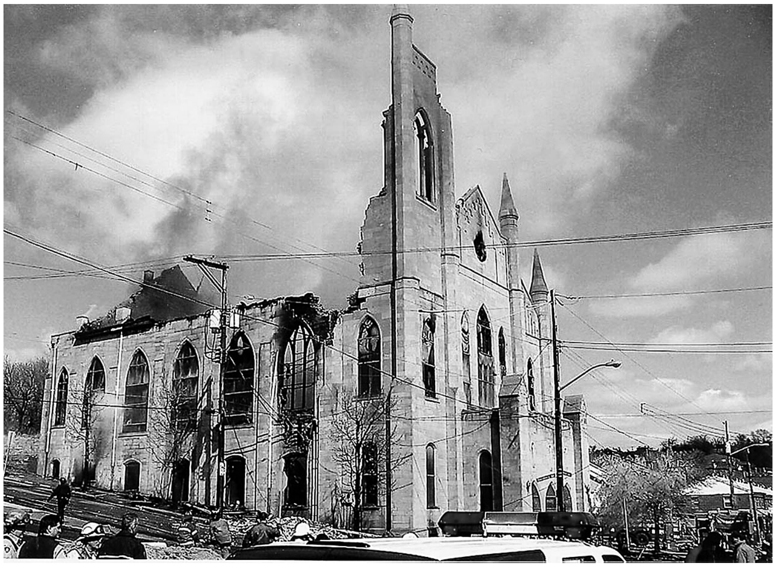


Fig. 7–2. The first attack hose team must extinguish the fire or change to a defensive strategy.

with an aggressive interior attack strategy, is more effective against residential building fires than those in worship buildings.

On arrival at a church fire, the first officer should locate and size up the fire to determine whether the blaze can be extinguished by a hose line; if the fire is too big, an exterior defensive attack should be the initial strategy (fig. 7–2). If the fire is extinguishable, the first line is taken into the building to the seat of the fire, and the fire is extinguished. The largest hose should be stretched to give the firefighter the most water power and the greatest reach. You get only one chance to extinguish a church fire. A second large-diameter hose line should immediately back up the first line. As soon as the flames are knocked down, the walls and attic should be check for concealed fire spread. If two hose lines do not extinguish a fire in a place of worship, firefighters should withdraw. Do not conduct a defensive attack from the inside of a church building as is done inside a multiple-dwelling or high-rise building. If two lines do not do the job, withdraw and fight the fire from the outside.

A chief officer or a veteran incident commander should be sent in to supervise the interior hose line attack inside a place of worship. A chief officer who has command experience and who has supervised both interior and exterior defensive firefighting can better evaluate and predict the success or failure of an interior hose line attack. A company officer who has experience only in single-unit operations may not accurately assess whether his or her own unit will be successful in controlling the fire.

Most fires in places of worship start in the basement and are caused by electric wiring or heating units. These fires spread up the walls and ceiling spaces to the main floor, and from there, they extend to the upper reaches of the building. The ceilings of most churches and synagogues are higher than a hose stream can reach. Thus, if smoke and heat start to bank up in the main service area (the nave or sanctuary) and it cannot be reached with interior hose streams, firefighters must withdraw. When the fire at the underside of the ceiling cannot be reached, notify the incident commander of the need for an outside attack strategy. If smoke and heat rise to the underside of the ceiling, firefighters operating hose line at floor level will not sense the buildup of heat. A flashover or backdraft conditions could develop over their heads, and when the ball of fire or explosion occurs, it will radiate fire and heat downward, trapping them inside the fully involved structure.

Another reason why interior firefighting is unsuccessful in worship buildings is the rapid fire spread over the wall and ceiling surface of the interior. Some have the interior surface composed entirely of wood and covered by flammable tapestries. The walls may wood paneling, and the roof underside may also be wood, with roof trusses arches and purlins of wood timber. The wood walls have been polished over decades with flammable oils. Any fire will rapidly spread across the interior surface like flameover fire. In addition to the polish, the wax vapor from the offering candles have deposited a coating of flammable resin on top of everything. If the incident commander arrives at the scene and firefighters are operating hose line at the entrance of the building, this indicates that the interior attack has failed. Firefighters should be withdrawn from the steps near the front entrance, a collapse danger zone, and outside master streams should be set up around the building.

Search and rescue

The primary life hazard in a place of worship is the people inside the building during a fire. However, many worship buildings are unoccupied a good deal of the time. In these cases, the primary life hazard during a fire is the firefighter. If a fire occurs during a religious service or a community social event, when the building is fully occupied, evacuation and search-and-rescue commitment must take precedence over fire extinguishment. During an evacuation, particular attention should be given to moving people once they are outside. People must be moved some distance away from the building, the steps, and the area around the exits. If people are allowed to congregate outside during fire evacuations, it will slow the building evacuation and back up those inside who are still attempting to flee the fire. Police should be called to the scene and requested to keep the people moving away from the structure.

Because these buildings contain holy and sacred objects, there is an urge to save these irreplaceable items from the fire. This urge is especially strong when the congregation or their leadership requests such salvage. Every effort should be made to remove holy items from fire danger, but the incident commander must not risk life to save property, even if it is sacred. The freelancing actions of firefighters, officers, and sometimes even chiefs in attempts to retrieve sacred objects can cause the entire firefighting effort to fail, owing to lack of resources and lack of command and control; worse yet, it can cause the death of firefighters or officers who take unusual risks in a dangerous structure. The incident commander should not allow unusual actions, to retrieve religious items, that unnecessarily risk firefighter’s lives.

Forcible entry

Opening massive locked church doors with forcible-entry tools may not be feasible. Instead, search for a side door or a back door. This door should be forced open if necessary. The first officer inside the place of worship must locate the fire and notify the incident commander of the possible success or failure of an interior attack.

Venting a worship-building fire

Owing to the height of most places of worship, the steep slope of peaked roofs, and the thick slate or tile shingle on some roofs, sending firefighters to the roof to vent is not a good strategy. A 4-foot-by-4-foot opening near the ridge of a roof is not going to vent much of the smoke and heat from a 5,000 square foot open floor area with 50–75-foot-high ceilings. Also, even if the roof is vented, there may be a 10–20 foot attic space and floor with a ceiling below that could not be pushed down. This attic space and floor would negate the roof vent exhaust effects. In some modern worship buildings, there is no attic. Still, the small opening would not vent combustible gases from such a large assembly space in a typical place of worship.

Defensive operations

When the incident commander arrives at the fire scene and the first and second hose lines have been stretched and supplied with water, the strategy is to prepare for a defensive master stream. As long as you have sufficient resources to advance the interior attack lines, start positioning apparatus for the defensive operations. The interior attack may or may not be successful; this should not stop the incident commander from being proactive and planning for the defensive operation in case the hose attack fails.

If the building has a rose window (a large stained-glass window at the upper reaches of the front of the building), that is where the first aerial ladder should be positioned. An aerial master stream should be positioned in a corner safe area (where the A/B or A/D sides of the building meet), and the aerial platform should be supplied with a large-diameter hose and raised to the rose window. This window should be vented with a pike pole by a firefighter in the raised bucket. The entire window should be vented. This is the one window in a church or temple that is high enough and big enough to vent smoke and heat from the upper reaches of a burning place of worship. It can be vented faster than it takes for a firefighter to cut a roof opening. The primary venting of this rose window may also allow an aerial master stream to discharge a heavy-caliber stream into the upper portions of the church (fig. 7–3).

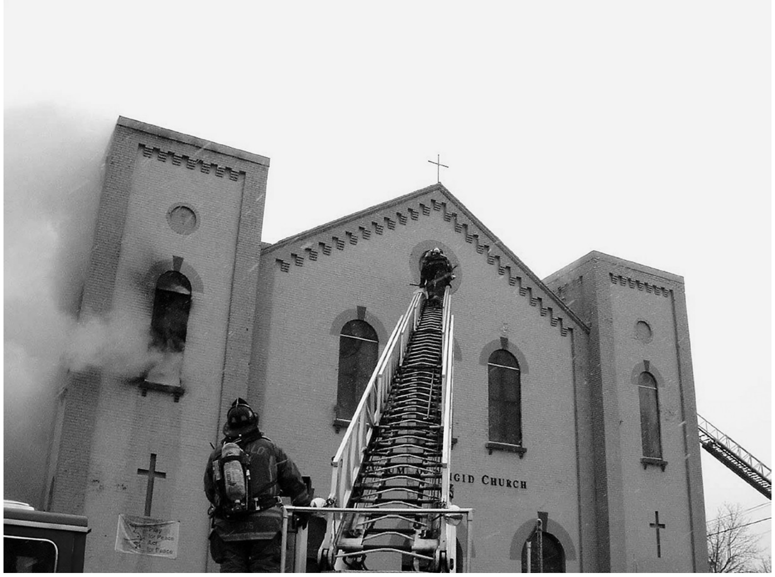


Fig. 7–3. Firefighters venting the rose window of a church.

The aerial master stream, shooting unimpeded 50–100 feet through a rose window, can sometimes break up fire and heat waves at the ceiling peak of the building, where the inside hose streams cannot reach. In some instances, a choir loft structure or pipe organ at the front of the sanctuary or nave will block the aerial master stream coming through the rose window. However, if there is no blockage, this single master stream may extinguish the fire at the upper peak near the ceiling and save the building. When inspecting a place of worship, examine the rose window and its possible effective use for venting and as access for an aerial master stream; it is always worth a try. After this aerial stream is in position, other master streams should be positioned around the structure—in parking lots and on the roofs of adjoining buildings—and used to protect exposures.

Window venting

After the rose window is vented, the decision must be made to vent the side stained-glass windows of the building, if they exist. The first two hose lines in a place of worship must extinguish the fire, or they must be ordered to back out so that a defensive outside attack may be started. During the initial hose line attack, venting may not be necessary, as the smoke and heat will rise up to the underside of the high ceiling. Smoke will not prevent firefighters from seeing or approaching the fire during the initial attack. If the fire is extinguished by interior hose lines, the side windows may not have to be vented. However, if the interior must be vented for the advance of the first two interior hose lines, the windows nearest to the fire on both sides of the building should be vented first.

If this venting the interior attack fails and the strategy changes from interior to exterior attack, the decision must be made by the incident commander to vent all of the side windows. At many churches and temples, the side windows are not stained glass and not valuable. However, in others, the side stained-glass windows are extremely valuable. Unfortunately, they must be broken. This creates a public relations problem, though, because the reason for the glass venting is not always understood by the public or parishioners. Parishioners sometime donate the money for each window and have their names on the windows.

One reason for window venting is that if you do not vent the side stained-glass windows and the building remains closed up, it may suffer a smoke explosion that could raise the roof and push out the walls. Also, if you do not vent the side windows, the fire may flashover when the firefighters are inside operating the hose lines. Furthermore, if you do not vent the side windows, the smoke and heat may bank down on the firefighters searching and operating inside.

Thus, during the initial stages, portable ladders should be raised to the side stained-glass windows near the fire and where the firefighters are operating the hose line inside. The first venting should be limited to the windows on both sides of the building near the fire inside. The opposite windows should create cross-ventilation. To vent tall windows, portable ladders or aerial platforms should be placed against the side wall, upwind from the stained-glass windows, and a firefighter on a ladder with a pike pole should break the windows.

Window venting should start near the top of the window and work down. This is because the smoke and heat will be near the top of the building's interior (fig. 7–4). Care should be taken, as the smoke and superheated gases flowing out of the vented windows may suddenly ignite on reaching the fresh air. Firefighters should try to be upwind from the smoke and heat.

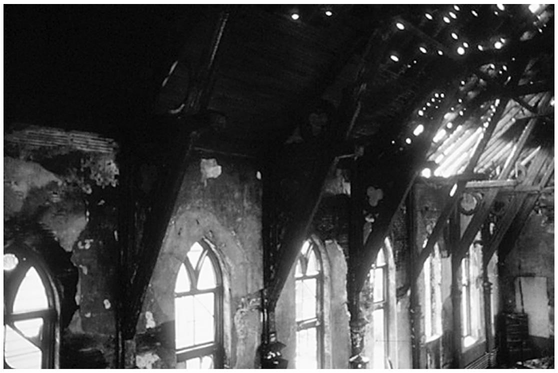


Fig. 7–4. Smoke, heat, and fire rise into the space above a church window.

When you analyze the top of the side stained-glass windows of most churches or synagogues in comparison to the height of the ceiling, you will quickly realize that if you vent a side window, this will not vent the smoke that is stratifying at the upper reaches of the interior, near the ceiling. When you look at the interior, you will see that the underside of the tall ceiling is higher than the topmost point of the side window. Even if all of the side windows are vented, the fire will stratify up at the underside of the high ceiling, above the top of the window, spread to the attic, and possibly flashover at the ceiling.

Protecting Exposures

Of the five types of construction (see chap. 3), places of worship are most closely associated with type IV (heavy timber buildings). The large amount of exposed wood interior surface, the heavy timber columns and roof beams, the large open spaces, and the large windows of most worship buildings resemble the characteristics of heavy timber buildings. Thus, when planning a strategy to protect exposures of a fully involved burning religious structure, plan in the same way you would for a burning heavy timber building.

Fully involved structures can spread fire to nearby woods in rural areas. The flames and radiated heat and burning embers coming from the burning wood interior in the countryside can start large brush and woodland fires if the structure fire is not contained. A burning building in an urban area can spread fire by radiated heat across a city street. When a defensive strategy is used, an incident commander should set up master streams in flanking positions, on each side of the fully involved building. Similar to the strategy for a wildfire, streams on both flanks of the burning building can control the downwind spread. During the free burning of the structure, fire, smoke, and flying brands will be flowing downwind. When the roof burns and the airborne burning ember are blown into the sky dispatch a fire company as a brand patrol downwind to extinguish small spot fires. When these burning embers fall to the ground or on the rooftops of buildings downwind from the burning structure, multiple fires can start. Master streams should be placed on three sides: upwind of the large fire and on both flanks. These master streams and the firefighters operating them should be outside the collapse danger zone. That is, they should be positioned away from the wall a distance equal to the height of the wall. When the roof collapses, it can push out any one of the four walls.

Interior Fire Spread

In the development of a defensive strategy for a worship-building fire, comparison is made to heavy timber (type IV) building construction. By contrast, in the development of an offensive strategy, comparison is made to ordinary (type III) construction. The inside walls, columns, and ceiling of a place of worship may look like stone. However, they may actually be plaster with wood lath covering concealed spaces and poke-through holes. Do not be fooled by this imitation stone veneer surface. As one firefighter who survived the Ebenezer Baptist Church collapse that killed two Pittsburgh firefighters said,

> *Beware of the house-of-worship stone veneer. This veneer makes the structure appear to be constructed of something other than it is. The church had a false appearance of solid limestone blocks 1 ft by 3 ft. This was only a facade and gave a false sense of security to the structure. We were under the impression the building was a lot stronger than it was and there was no way it could collapse.*

Behind a stone veneer could be a lath-and-plaster concealed space.

If the interior attack is successful and the fire is extinguished by the interior attack hose teams, firefighters should immediately try to open up the walls and ceilings near the smoldering fire. Check the concealed spaces for fire. If fire spreads to the concealed spaces, it may spread upward, to the large attic space. Flames may spread to an attic through the hidden voids behind the side walls, through hollow imitation-stone columns, and through small ceiling-level holes around chandelier lights. In addition to opening up the concealed spaces after a fire is extinguished, firefighters should quickly gain access to the attic space and check to see if fire has already spread to the large concealed space. Finding the stairway that leads up to the attic may take some time, and climbing narrow spiral stairs may slow the firefighters; nevertheless, this is an important action. If the fire is in the attic, the ceiling could collapse, or the truss roof beams could also fall and trap firefighters below. If fire is allowed to spread unnoticed in the attic, there could be a collapse on firefighters performing salvage, washing down burned content, and overhauling.

Collapse Dangers

Tower and steeple

Structural engineers have identified towers and steeples as one of the most unstable features of a worship structure during an earthquake. The tower is the square structure rising above the roof. Sometimes there is a steeple atop the tower. The steeple is the tapered pointed structure on top of the tower. The steeple tip may have a cross or other religious symbol. On a temple, the tower may have a domed pointed sphere at its top. A steeple on a tower is more unstable than a domed tower. When the steeple is located at the front of the structure, this exposure A wall must be considered a collapse danger.

Side wall and roof collapse

The roof of a worship structure with a peak is supported by the side walls. Side walls that run parallel with the peak ridge are the bearing walls (fig. 7–5). A bearing wall supports a weight other than its own weight—in this case, the weight of the roof. These side bearing walls are primary structural members. A primary structural member supports another structural member. What does all this mean to an incident commander? It means that if the roof burns and starts to collapse because it is interconnected, it could push out the side walls. Conversely, if a wall fails, the roof would lose its support and collapse into the floor. Because of the steeple and the interconnection of the roof and side bearing walls, exposures A, B, and D of a burning worship structure are the most dangerous areas during a fire.

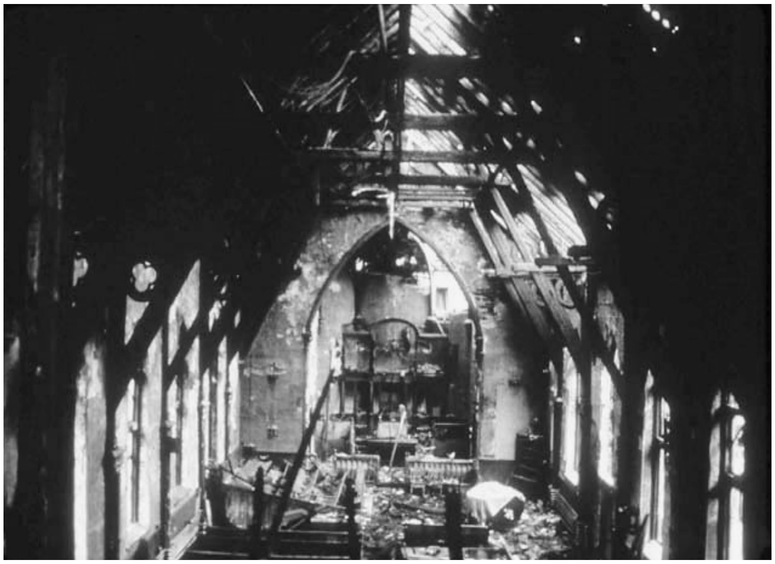


Fig. 7–5. The side walls support the truss roof of a place of worship.

Ceiling collapse

If the fire spreads to the attic, there is plenty to burn. In an attic of a structure with a Gothic plaster ceiling beneath a peaked roof—for example, Saint Patrick Cathedral, in New York City—there are tons of wood. In the attic are two-foot-thick timber truss beams; the plank wood underside of the roof deck; a wood lath covering bent to the shape of the plaster Gothic arch ceiling below; and a wooden walkway from the back to the front of the attic space. If fire reaches the attic spaces of these buildings, it cannot be extinguished with handheld hose lines. Access to the attic space is through one small door, and there is no possibility to vent. Firefighters will have to be withdrawn, and a defensive attack using master streams strategy will have to be used.

Before the roof collapses, the ceiling may collapse. If a large part of the ceiling collapses, it will create an explosion-like eruption inside the building that will blow out windows and knock firefighters off ladders. As a large, high ceiling collapses, superheated air, smoke and flame are compressed below the falling ceiling, inside the building. This compression can blow out windows. The collapsing ceiling will also create a vacuum above the ceiling. This instant vacuum sucks air into the now-open attic space, creating a flashover of the superheated smoke and fire gases that accumulated in the attic before the collapse.

Conclusion

An added danger of fighting a fire in a place of worship is the emotional factor. Many firefighters attend religious services, and some firefighters at the scene may even attend the place of worship that is burning. When a religious structure burns, it usually attracts the local members, and they watch as their holy place of worship is destroyed by fire. Inside the burning building, there are sacred books, scrolls, and artifacts and symbols with huge emotional and spiritual meaning to the members. This sometimes leads incident commanders, sector officers, fire officers, and firefighters to take risks that would not be taken at an ordinary public residence or commercial building fires. Again, even at a worship-structure fire, firefighters must remember their priorities: first priority is life hazard, including the lives of firefighters; second priority is incident stabilization; and property protection is the last priority, even in a place of worship.

8 RESTAURANT KITCHEN FIRES

When a fire officer is assigned to a downtown area in a city where there are offices, shops, and theaters, there will also be restaurants—plenty of restaurants. And there will be plenty of restaurant fires.

A fire in a restaurant usually starts in the kitchen. The kitchen fire most often occurs on or near the stove. Further, the stove fire may spread to the exhaust ducts and, from there, to the entire building.

Firefighters who work in downtown commercial districts call the restaurant kitchen fire the "rich person's food-on-the-stove" fire. The response to restaurant kitchen fires in the theater district will be just as frequent as response to a food-on-the-stove fire in a residence area. Unlike a residential kitchen fire, though, if the incident commander does not use the correct strategy at a commercial kitchen fire, this stove fire can spread to the entire building, cause an explosion, result in a panic for the restaurant patrons, and become deadly.

Restaurant fires occur during busy cooking times in the afternoon and at dinner time. Office workers eat lunch in restaurants, and in the evening, restaurants cater to theater-, movie-, or concertgoers. It has been my experience that some of the fanciest and most famous restaurants have the most hazardous kitchens. The busier the restaurant is, the more the stove will be used and the more likely the stove exhaust hoods, grease filters, and exhaust ducts will not be cleaned—and thus, the more likely there will be a fire. The incident commander must learn a new firefighting strategy to stop fire spread in restaurant kitchens.

The hose placement strategy for fighting a commercial kitchen stove fire is different than the hose placement strategy for fighting residential kitchen fires. Furthermore, at a restaurant kitchen fire, venting is different and the use of ladders is complex. Also, because of our experience with the residential kitchen fire, the commercial restaurant kitchen fire sounds like an easy fire; however, this is not true. The commercial kitchen fire can be deadly.

Explosions, reflash fires, boilover oil scalding dangers, and ceiling collapse are some of the hazards of fighting commercial kitchen fires. Three FDNY firefighters, Lieutenant Joseph Beetle and firefighters Stanley Skinner and Thomas Earl were killed when caught beneath a ceiling collapse. The fire was caused by a restaurant stove fire that spread into the concealed space above a ceiling of the adjoining store (fig. 8–1). While pulling tin ceilings in an adjoining store, they were trapped after the ceiling collapsed. Restaurant kitchen stove fires, exhaust hood fires, and grease duct fires will be a common response. Restaurant kitchens use the stove seven nights a week, and they may not clean the grease filters over the stove.

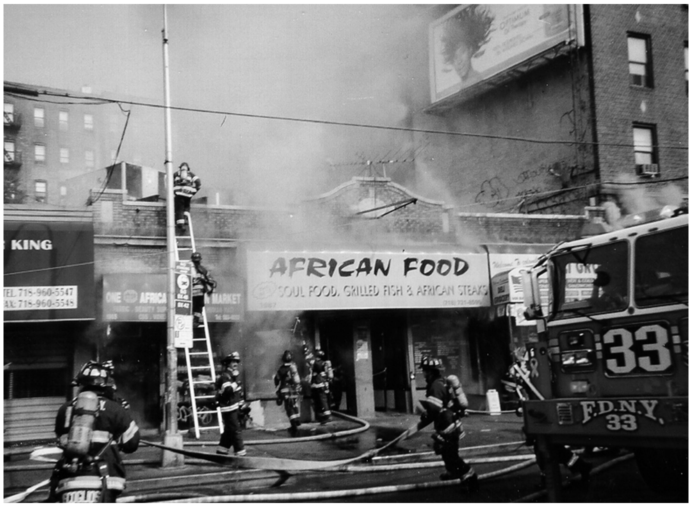


Fig. 8–1. Restaurant kitchen fires usually occur in the kitchen stove and spread to concealed spaces.

The exhaust hoods and grease filters inserted into the exhaust hoods over the stove are designed to keep evaporating fats, grease, and cooking oils from entering the exhaust duct, which is a sheet metal ductwork extending from the kitchen to the roof. Sometimes this exhaust duct extends several floors from the kitchen to the roof. If grease accumulates in the duct, adhering to the inside of the ducts at corners (where it changes direction and must travel horizontally before it reaches the roof), a serious blaze can take place, and if it extends out of the ductwork on several floors, the entire building can burn down. The kitchen fire is easy to extinguish, but the duct fire is a little more difficult to quench. Moreover, if the fire extends from the ducts and breaks out on every floor and in the cockloft, the kitchen stove fire becomes a major-alarm fire.

There are many problems that arise during the kitchen stove fire:

- Explosion of stove gas
- Boilover of deep fryer oils and fats
- Control of fans that spread fire throughout ducts
- Tracing the ductwork several floors throughout the building
- Simultaneous fires on several floors
- Getting keys (or forcible entry) to gain access to rooms and offices near the ductwork
- Fire spread to concealed spaces
- Ceiling collapse
- Evacuation of diners from the restaurant during their meal

The incident commander must make several quick and correct strategy decisions, or such a fire will spread rapidly. The first and most important decision must be to summon additional resources to the scene.

Size-up

The first two size-up facts that the incident commander must determine at the scene of a restaurant duct fire are the type of building construction housing the restaurant and whether the exhaust ductwork runs up the interior of the building to the roof or whether it is attached to the outside of the building. The construction of the building determines the likelihood of fire spread throughout the building and out the ductwork. If the construction is wood frame, ordinary, or heavy timber, the chance of fire spread is high. If the construction is noncombustible or fire resistive, the chances of fire spread from the ductwork to the structure is low. Also, if the ductwork extends from the kitchen to the roof on the interior of the structure and is enclosed by combustible framing, then the possibility of fire extension from the ductwork to the structure is high. However, if the ductwork goes from the kitchen exhaust duct to the roof by attachment to an outside wall, then the chance of fire extension from the ductwork to the building is small.

Building construction

If a duct extends from the kitchen to the roof inside a wood frame (type V), ordinary construction (type III), or heavy timber (type IV) building, you have big problems. You have to trace the ductwork behind walls and ceilings, and this takes time. The time that it takes to trace the ductwork may allow fire to spread to a concealed space.

The construction of the building determines the likelihood and speed of spread of a grease duct fire to the building. Restaurants in a wood frame or ordinary construction building provide the greatest chance of fire extension from the ductwork to the building. A heavy timber building that does not have concealed spaces has less of a chance for serious fire spread. Noncombustible (type II) and fire-resistive (type I) buildings have the least danger of fire spread from the kitchen or duct fire. In noncombustible or fire-resistive buildings, the hot duct will be enclosed by noncombustible materials. Fire spread from the hot duct to the structure is small. In these buildings, you worry about gas explosion, boilover of oil, ceiling collapse, and a panic of restaurant guests if the smoke quickly spreads from the kitchen.

Fire spread from a stove

The kitchen is usually on the first floor, but occasionally in the basement of a one- or two-story wood frame building, a three- or four-story ordinary construction building, or a renovated five-story heavy timber building. In any of these combustible buildings, interior fire spread may travel as follows: from the stove to the grease duct, igniting the grease inside the duct and then spreading out one or more floors above the kitchen, including the common roof space; if the exhaust duct terminates near a window or the air intake of an adjoining building, flame may spread to that exposed building.

Automatic Fire Systems

In many kitchens, there is a fire-extinguishing system that on sensing a fire, automatically discharges the extinguishing product on the stove, shuts off the fans in the exhaust duct, and shuts off the gas supply to the stove. However, some kitchens do not have this auxiliary fire protection, so the first-arriving units at a restaurant kitchen stove fire should check to see if there is a fire protection system and determine if it has been discharged. If not, activate the control to the extinguish system manually. Also check to see if duct fans are still flowing air from the stove to the duct system. If the exhaust fans are still operating, shut them off, because they may be spreading the fire from the kitchen to the ducts. The fan shut-off and fire extinguishing controls to a restaurant stove are usually located near the kitchen entrance. The manual activation of the fire-extinguishing system will stop or at least slow the fire spread into the grease duct. In addition, if the stove is gas fired, the officer should ensure that the gas supply to the ovens and stoves is shut off. Gas shut-off will prevent an explosion if the hose stream accidentally extinguishes the gas jets (fig. 8–2).

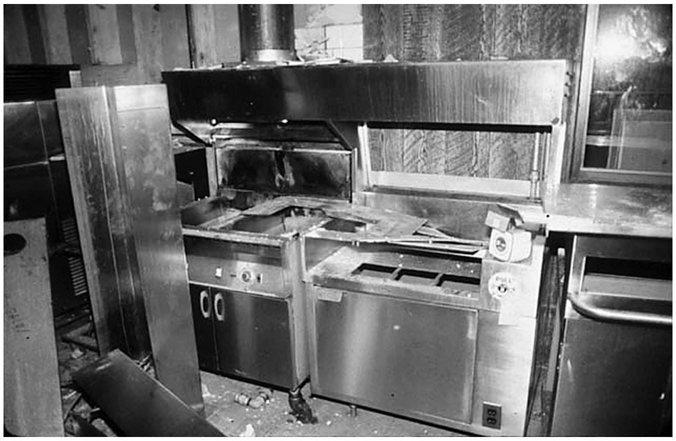


Fig. 8–2. The stove gas must be shut off to prevent an explosion.

Kitchen Explosions

A gas explosion is a violent combustion reaction of gas, oxygen, and heat, creating a rapid expansion of gases strong enough to collapse ceilings and parts of the kitchen walls, break windows, and knock firefighters directing a nozzle to the ground. If after extinguishment of a stove fire there is a gas fire fed by a broken gas pipe or from the gas jets, do not extinguish the flame; let the gas fire burn. The strategy is to let the fire burn and shut off the source of gas supply. If there is no gas shut-off visible in the kitchen, the incident commander should order a fire company to shut the gas supply off at the building inlet.

Reflash Fire

Also called a flashback fire, this is the sudden ignition of gas or combustible gases from the grease fire, just after the initial fire has been extinguished by the hose stream. After the fire has been knocked down and the hose stream has been shut down, there may still be sufficient heated gases and nearby hot metal of the stove; boiling oil can also cause the kitchen to reflash and burn firefighters making a quick survey of the grease hood.

Grease and Oil Fire

The kitchen stove fire is a class B flammable liquid fire. If the first-arriving firefighters have portable carbon dioxide or dry chemical extinguishers, these should be the first choice. However, if class B extinguishers are not available, a fog nozzle should be used to extinguish oil and cooking grease fires—for example, to put out a fire in a deep fryer.

The water fog stream should not, however, be directed into the deep-fat fryer or pots of oil. This action could create a boilover. A boilover is a sudden eruption of hot oil over the top of large pot of oil. A boilover could occur after water from a hose stream sinks to the bottom of the burning oil and is heated to its boiling point. As the water turns to steam and expands by 1,700 times, it can cause a boilover, which could spray boiling oil over firefighters operating hose lines in the kitchen.

The fog stream should be directed back and forth over the burning oil. Do not drive the fog stream into the burning liquid. Allow the fine droplets to cool the flames above the oil. Water of fog hose streams extinguishes fire by removing heat. Water cooling reduces the temperature of the fire. A fog stream quickly turns to steam. The steam reduces the oxygen near the fire during the conversion of the water fog stream into steam. Evaporation of the water into steam absorbs the heat.

If the nozzle is a combination fog and straight stream, then after the stove pot, oil, or grease fire is extinguished, a solid stream can be directed into ceiling or into the exhaust duct through the grease hood. The reach of a solid stream allows firefighters to stay a safe distance from the fire. After the fire is extinguished, the ceiling around the stove should be opened to examine for any fire in the concealed spaces.

If the fire spreads to a combustible ceiling framework, it becomes a class A material fire. This is when flames are spreading in combustible wood, paper, or fabric; water is required to extinguish such a blaze. There are many types of combustible materials in a commercial kitchen that may require different type of extinguishers. Whereas extinguishment of class A materials require water, extinguishment of class B materials (oils, cooking grease, and flammable liquids) requires carbon dioxide or dry chemical extinguishers or fog. If fire spreads to the electrical equipment (e.g., electronic panels on a stove), this is a class C material fire, and extinguishment requires the use of the carbon dioxide and dry chemical extinguishers, as on the flammable oils and grease. Shut off the electric power at the same time, and do not use water on an electrical equipment fire. Class D materials are combustible metals and requires a dry powder extinguisher.

Venting

Venting windows to reduce smoke is not a priority during the initial stages of a commercial kitchen fire. In fact, at a kitchen fire, we want to stop air movement. Vent fans are shut off to keep the fire from spreading through the grease filter and ducts.

A typical fire in the restaurant kitchen is a flash fire. Smoke is not a problem at a kitchen fire. The incomplete combustion of ordinary combustible material during the growth stage of a fire is where most smoke is generated. A kitchen flash fire in flammable liquids will not have a growth stage, so the generation of large amounts of smoke is not a problem. Thus, venting is not critical during the initial phase of restaurant kitchen firefighting. Because there is little smoke, visibility near the fire in the kitchen will be pretty good. Venting may be required for the steam generated during the fire extinguishment and the heat given off from the stoves and ovens, but not for smoke. Venting will definitely be required if the fire spreads from the ducts to concealed spaces of an ordinary construction or wood frame building.

Firefighter Falls

If the restaurant is a one- or two-story building with a peaked roof and the duct terminates on the roof, firefighters sent to the roof should use caution when moving on the uneven roof surface. The roof surface maybe coated with grease, and firefighters can easily lose their balance and slide off the roof. Ladders should be used to reduce the danger of falling off the slippery roof.

Fire Spread and Collapse of a Kitchen Ceiling

As soon as the stove fire is extinguished, check the ceiling around the grease hood. Pull the ceilings near the fire. Flames may have spread to the concealed space above the ceiling. The space above the suspended ceiling should be examined for signs of fire spread. To reduce the danger of a ceiling collapse, firefighters should extinguish the fire in the stove before it can burn through a ceiling. As soon as the fire is extinguished, start opening the ceiling and walls around the stove to check for fire spread.

In some kitchens, there are multiple ceilings. One ceiling is suspended below another ceiling during kitchen renovations. Open up all ceilings until you see the floor or roof beams above. Firefighters should work together to pull down the ceiling. Care should be taken not to pull down the ceiling support framework. Pulling down the ceiling supports could trigger an entire ceiling and supporting framework collapse; just open the ceiling panels.

Ornamental, tin panel ceilings are often found in kitchens for their fire-retarding effects. They are difficult to open with pike poles. If the ceiling in the kitchen is a tin panel ceiling, the procedure is to poke up the ceiling near a seam. This will provide a small opening in which to insert the pike pole. Pull sheets of tin down to observe the area above the suspended ceiling.

Check for hidden fire spread. Once the ceiling is open to the perimeter of fire spread, use the hose streams to extinguish fire in the concealed space. If the ceiling is weakened by fire, limit water from the hose stream directed toward the ceiling. A hose stream delivering a ton of water per minute could overload the ceiling supports and cause a collapse. If fire has spread to the ceiling and is spreading, then notify the incident commander to have a company stretch a hose line to the floor above, in case the fire has already extended there. This important information about spreading fire will affect the chief's decision as to whether to order the evacuation of patrons from the restaurant.

After the stove and grease hood fire has been extinguished, the ductwork should be immediately traced throughout the building. The duct from the grease hood will travel up the interior or the exterior of the building and terminate on the roof; as soon it has been determined to be inside or outside (attached to the building), this information should be reported to the incident commander. Also, if it is suspected that fire has spread past the filters of the grease hood and is traveling up the duct system to the roof, this too should be reported to the command post. A hose line must be stretched to the roof, and the stream must be directed into the duct. This will extinguish a fire in a duct more thoroughly than the hose stream in the kitchen can. There are usually bends and fan housing above the grease hood that can prevent stream penetration from below; by contrast, gravity helps the hose stream above extinguish the grease fire in the duct. There is a theory that if a fog stream is directed into a duct or a chimney, evaporating water will rise up and extinguish any fire in the vertical duct or flue; however, a hose stream on the roof is more dependable. In a one-story building, this will be a simple task, but if the ductwork extends over several stories throughout the interior of the building, this will be a major task.

If the building has a standpipe, the top-floor hose or a hose from a roof manifold may be used for the roof hose line. If the duct extends up the interior of the building and is built into concealed spaces on every floor and it appears that fire is spreading, access to every intermediate floor is required, and the area around the duct must be examined. When it is known that ducts extend up the interior of the building and not outside, during the early stages of the fire, keys should be obtained from the management, to reduce damage from forcible entry. If the presence of smoke or heat is indicated by a burn mark on a ceiling or wall, or if a hot spot is detected by a thermal-imaging camera or by the touch of the hand, then the wall or ceiling must be opened, and the partition wall enclosing the duct must be examined. Next, the interior of the duct may have to be examined through an access panel or by cutting the duct.

If the duct is attached to the exterior of the building, it will be easy to trace the duct to its termination, and whether fire is burning inside the duct can be easily determined. Any hot spot may be seen from the street or an aerial ladder if necessary. If the metal duct on the outside of the building is red hot and it is attached to the combustible exterior of a wood frame building, then the space behind the duct and the building may have to be examined; if necessary, a hose stream should be directed to this space, and the wood exterior shingle may have to be removed to check for extension. Even if the duct is attached to the outside of the building, a hose line will be required at the duct's termination.

Hose Stretching

The hose-stretching strategy at a restaurant kitchen fire that has extended into the duct and is burning grease in the duct is as follows: The first line goes to the kitchen; the second line goes to the roof near the duct's termination; and the third line goes to the floor above the fire or any floor where it appears that fire has spread from the ductwork. This hose-stretching strategy is different from that employed at most structure fires. At most structure fires, the first line goes to the fire floor, the second line backs up the first and then goes to the floor above, and the third line goes wherever the fire is spreading. At a restaurant fire, a ground ladder should be positioned on the roof for hose stretching to the duct termination at a one- or two-story building; an aerial ladder may be extended to the roof of a multistory building for hose stretching to the roof. If an aerial ladder is used for hose line stretching, another ladder should be called to the scene and positioned for possible rescue of occupants or firefighters who suddenly become trapped above a kitchen restaurant fire that spreads.

If the stove and grease hood fire is extinguished and there has not been fire extension to the ceiling but it appears that fire is spreading in the ductwork up to the roof, the incident commander should order for a company to stretch the second hose line to the roof and the restaurant to be evacuated (fig. 8–3). Water from the second hose line should be directed down the duct. Any burning grease attached to the inside of the duct will be quenched by this hose line.

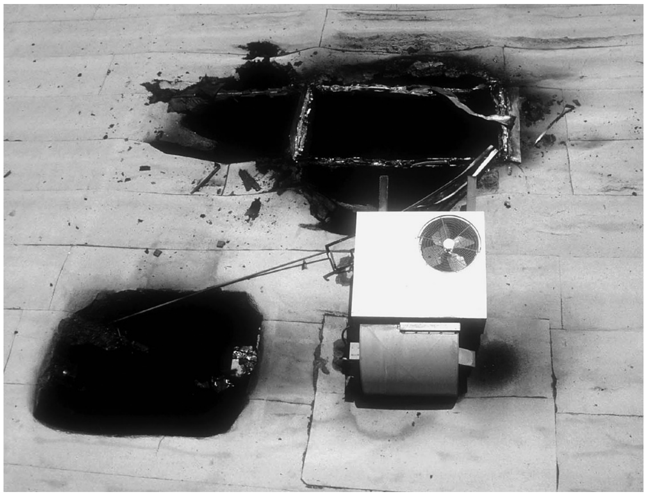


Fig. 8–3. This restaurant kitchen fire has spread to the roof.

Fan Housing

Somewhere above the grease hood, there will be a fan housing in the duct to the roof outlet. In this housing lies the fan that draws the heat from the stove through the exhaust hood. The fan housing can be located above the exhaust hood or near the duct termination at roof level. Either way, the controls to the fan are located near the kitchen entrance.

The fan should be shut off by the first firefighters on the scene entering the kitchen. After the fan is shut off, the fan housing in the duct just above the grease hood may also temporarily block the grease fire from extending to the duct. However, do not depend on this. Check the duct termination on the roof to see what is coming out. After the fire has been extinguished, a fire officer on the roof should continue to analyze the heat and steam coming from the duct termination on the roof. This is where any smoldering fire in the ductwork will be detected; the smoldering fire will not be detected in the hot kitchen by firefighters.

Heat rises and, hence, the duct opening on the roof will provide the best indication of whether fire extinguishment has been achieved. To prevent the possibility of leaving the scene and being called back because of a rekindle, the incident commander should request a progress report from the fire officer on the roof. Request a size-up of the exhaust fumes coming from the duct opening. If there is any sign of heat or the smell of smoke or grease burning, have companies recheck the ductwork where it travels in a horizontal direction or where it changes direction—that is, where it is most likely that there is an accumulation of grease. A smoldering fire may continue to burn at such a location. Thus, when heat and smoke continue to flow from the duct's termination on the roof, despite the use of hose lines at the top and bottom, the ductwork should be opened where it bends or runs horizontally, and water. Cut open the metal duct or use a cleaning or access opening to examine the interior. Water from a hose stream should be sprayed at this point in the ductwork.

Evacuation

If the kitchen fire occurs during lunchtime or in the evening, when the restaurant is full of diners, the incident commander may have to order all the diners to evacuate the building during the fire. This will be difficult. The people will not want to leave if they are in the middle of eating dinner. And the restaurant management will not want the patrons to leave if the bills have not been paid. Even if the diners want to leave, they may want to reclaim their coats or use the restroom first. The prompt notification and evacuation of the restaurant occupants is a very important lifesaving action during a restaurant kitchen fire.

Drapes, tapestries, and other decorative materials can be highly flammable and may quickly spread fire throughout the restaurant before people can get up from their tables. At the Happy Land Social Club fire in New York City, victims overcome by smoke were found at the seats with their heads on the tables, as if they were sleeping. At the Station nightclub fire in West Warwick, Rhode Island, the exit doors became clogged with people fleeing the fire within five minutes.

A light smoke condition in the kitchen can change quickly and spread to the dining area through the concealed space above a ceiling if the kitchen is not separated by floor-to-ceiling fire partitions. When flames become visible or smoke blocks visibility, the guests may panic, and the restaurant kitchen fire could become a deadly scene. If the restaurant is crowded and the fire extends to the ceiling space or duct system, the incident commander should start evacuation. After the fire is controlled, diners can be allowed back inside to get their belongings.

The restaurant employees should be requested to assist with the evacuation. If the staff are trained, they can save live and prevent injuries by ushering people safely to the exits. The restaurant employees may know of exits not visible to the diners. During the evacuation, have someone check restrooms and coatrooms for patrons. The simultaneous operation of kitchen firefighting, tracing the path of the exhaust ducts, stretching lines to the duct's termination on the roof, evacuation of the restaurant, and preventing possible fire spread to above floors requires quick decisions be made by the incident commander, as well as by firefighters. The incident commander should be proactive about calling resources to the scene. Transmit greater alarms to reinforce the first responders.

Fire Protection

The fire danger in a restaurant is in the kitchen. If there is a smoke condition in a restaurant after hours, check the kitchen area around the stove, the exhaust hood, and in the concealed space above the ceiling. Most restaurant fires start in the kitchen of a restaurant, not the public eating area. Therefore, the kitchen should be divided from the dining area by fire partitions, and these walls should extend from the floor to the underside of the floor above, with no opening.

The kitchen area should also be protected with an automatic extinguishment system. The dining area need not have this protection. The stove and hoods should have a CO_2 or dry chemical system to extinguish a stove flash fire. Furthermore, the controls of the system should shut off the exhaust fans, and when the fire extinguishment system is triggered, the gas to the stove must be shut off. If the gas flame is extinguished and the gas continues to flow, an explosion can occur. The manual controls to the system should also be located by the door. Employees fleeing the fire and firefighters responding to the kitchen blaze should have access to these manual controls of the fire-extinguishing system and the gas shut-off.

Delayed Alarm

A large restaurant can be a place of assembly, and there is always concern when large numbers of people gather in one place. Most building codes consider places of assembly as those with occupancy over 50 people. The New York City building code declares a restaurant as a place of assembly if it fits more than 75 occupants. In a place of assembly, the capacity of the exits, the aisle space, and a method of alerting the occupants in case of emergency are important. The occupants of a restaurant are not as familiar with the exit paths and may be late in recognizing the alarm warning, and some may be intoxicated and not respond to directions. Restaurants are dark by design, as patrons want subdued lighting while dining.

If a fire is detected, the restaurateur may be reluctant to have the people leave. Consequently, the employees may try to fight the fire, and there may be a delayed alarm—that is, the fire department is not notified at the first sign of fire. The first-responding firefighters may find a large spreading fire in the ductwork and throughout the restaurant, diners in a panic, and severely injured kitchen staff.

9 FIRES IN TRUSS BUILDINGS

There are three types of trusses that kill firefighters, and there are three ways firefighters die when trusses collapse. There are three strategies firefighters can use to survive a truss collapse. Do you know what they are? Most firefighters do not.

From a firefighting point of view, a truss is the most dangerous structural element of a building. A truss can suddenly collapse during a fire, and when it collapses, it can push out a wall. Truss construction used as roof and floor beams collapse and kill firefighters operating on top of a truss, kill firefighters operating below the truss, and kill firefighters operating outside burning truss buildings. The three types of trusses that collapse and kill firefighters are as follows:

- Timber truss roof systems
- Lightweight wood truss roof and floor systems
- Steel bar joist truss roof and floor systems

Timber Truss Roof Systems

A truss is defined as a structural composition of wood or steel joined together in groups of triangles, arranged in a single plane, so that loads applied at points of intersecting members will cause only direct stress, such as tension or compression (fig. 9–1). Most building codes define timber as wood at least four inches wide and six inches deep. Steel bolts and plates are used to connect timber trusses. The timbers in a truss are joined together by bolts that pass through the center of a steel

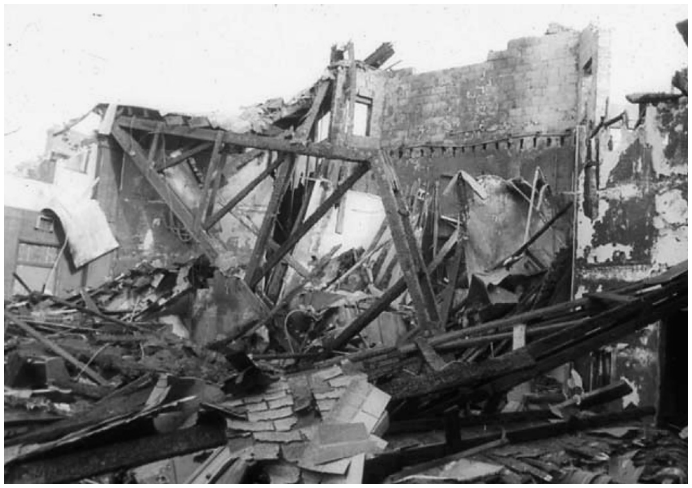


Fig 9–1. This timber truss is a designed for a gable roof.

plate. The most common connector is the split-ring metal connector. The split ring is a steel ring that is embedded in prepared depressions on the face of the timber. Its purpose is to relieve the bolts connecting the truss sections from shearing stress. A timber truss roof can be built in a variety of shapes.

The bowstring timber truss is the most common design. Its curved top chord creates an arched roof; its bottom chord is horizontal timber. Both chords outline a bow with a string attached to each end. The wooden web members connecting the top and bottom chords are of smaller dimensions; however, they are critical to the overall strength of the truss section during a fire. When attacked by flames, the entire truss section may fail as soon as the smallest web member weakens. In other words, under fire conditions, the truss is only as strong as its weakest member.

Wood timber truss construction is used to span the roofs of large-area buildings. When a 100-foot timber truss, 20 feet on center, fails, it causes 4,000 square feet of the roof area to collapse. Occupancies that require large open floor spaces use timber truss roof supports. There are no supporting columns needed with the long span timber truss roof supports. Occupancies that use timber trusses include supermarkets, bowling alleys, garages, auto dealership showrooms, theaters, churches, skating rinks, and piers.

The timber truss roof has been known to collapse suddenly during the early stages of a fire. In 1988, a Hackensack, New Jersey, Ford auto dealership truss roof failed, killing five firefighters 35 minutes after arrival of the first company. In 1978, in Brooklyn, the roof of a Waldbaum's Supermarket failed, killing six firefighters 32 minutes after arrival of the first units. In 1966, the truss roof of a Cliffside Park, New Jersey, bowling alley failed, killing five Ridgefield firefighters 30 minutes after arrival. The lesson learned from the 1966 Cliffside Park, New Jersey, truss roof collapse is that when a truss roof fails during a fire, it may cause the secondary collapse of one of the masonry enclosure walls.

These examples illustrate the three ways firefighters can die when operating at fires involving timber truss roof buildings are as follows:

- Firefighters operating on the roof above a burning timber truss can fall into a fire when the roof collapses. This is the way the FDNY firefighters in the Brooklyn supermarket fire died.
- Firefighters operating below a timber truss roof, inside a burning building, can be crushed and burned to death when the collapsing truss roof falls on top of them. This is the way the Hackensack firefighters died.
- Firefighters can be killed while operating outside a burning timber truss roof building. When trusses collapse, they may push out a masonry wall (fig. 9–2). The timber roof trusses can collapse and cause a secondary wall collapse. The firefighters from Ridgefield, New Jersey, were crushed beneath a falling wall pushed out by the falling truss roof.

The timber truss roof has left a record of death and destruction in the fire service along the East Coast. The death and destruction has mainly taken place where the buildings are older and, in some instances, suffer from neglect and improper alterations. Unfortunately, the South and on the West Coast are starting to experience this event as their newer timber truss buildings age and fall into disrepair.

Examples of timber truss roof collapses from the 1960s, '70s, and '80s have been

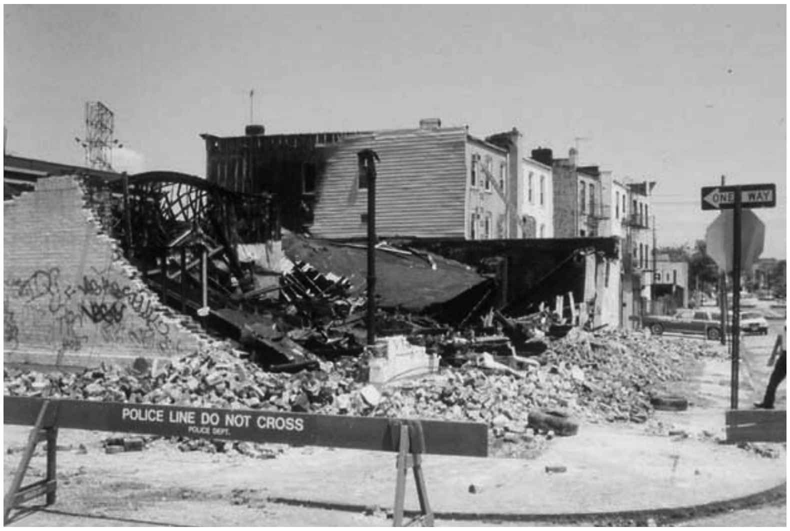


Fig. 9–2. This bowstring truss roof collapsed, pushed out the wall, and injured two FDNY firefighters operating a hose line outside the building.

described already. In addition, in the 1950s, two firefighters from Highland Park, New Jersey, died in a timber truss garage roof collapse; they fell into the fire while operating on the roof. In the 1980s, two Valley Stream, New York, firefighters died when a synagogue roof collapsed on top of them. In the 1990s, Los Angeles Fire Captain Joseph Dupree was killed while operating inside a timber truss building when the roof collapsed.

Lightweight Wood Trusses

The use of lightweight wood truss construction has exploded in this country, and so has its danger to firefighters. Small wood truss construction is used in residential and light commercial construction today. The smallest dimension of a wood member in a timber truss is four inches; the largest dimension in a lightweight truss is four inches. However, the concern to the fire service about lightweight wood truss construction is not the size of the wood. The concern is the truss connections.

During a fire, a building element usually fails at the connection. Sheet metal surface fasteners are used to connect the small wood truss members together. Instead of thick steel plates and bolts, thin pieces of sheet metal, called *surface fasteners*, connect the outer half-inch surface of wood truss members. The sheet metal surface fastener is a deficient structural connection from a fire protection point of view (fig. 9–3).

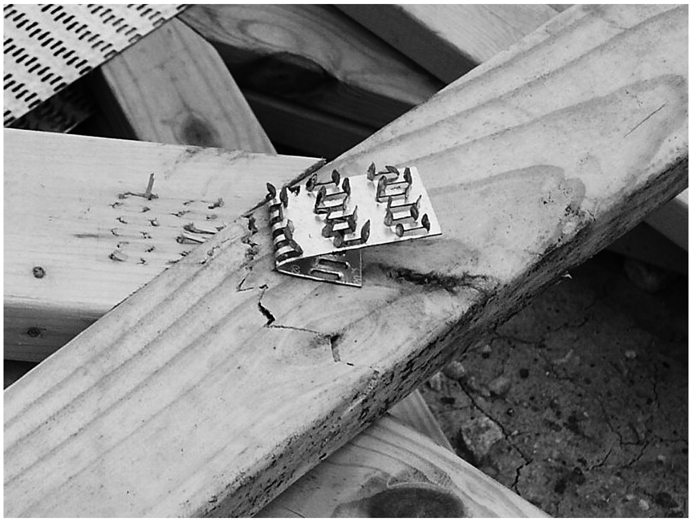


Fig. 9-3. The sheet metal surface fastener connection fails during the early stages of a fire.

The design of the small wood truss can be defended from an engineering viewpoint, but no architect, building contractor, or code official would defend the sheet metal surface fastener.

The surface fastener is a dangerous structural connection. During a fire, the points of connection are the first to fail. The most serious defect in the surface fastener that connects lightweight wood trusses is the insufficient depth of penetration of the nailing points. The V-shaped nailing points enter the wood to a depth of only a half inch. During a fire, when the outer layers of wood char, the surface fastener loosens more quickly than would a nail or a steel bolt, which penetrates the entire thickness of truss members. In addition, even if the fire is not of sufficient intensity to char the wood, heat from the flames can warp the thin sheet metal surface fastener and cause it to curl up and pull away from the wood truss.

Lightweight wood trusses are prefabricated at a factory and shipped to the construction site, where they are stored until needed. If these trusses are improperly transported or stored at the site or if they are dropped or handled roughly, the metal surface fastener can pull away from the wood surface or become loosened. In such instances, the truss has been weakened even before it is installed in the building.

There is also no standard size for the connectors. The size of a sheet metal surface connector varies from one and a half inches by three inches to three inches by four inches. The variously sized sheet metal surface fasteners have replaced the standard eightpenny nail.

The sheet metal surface fastener has been permitted as a truss connector after passing a century-old furnace test and receiving the approval of the so-called performance code advocates. Building design professionals in the past have decried the restrictions of the older building code, requiring little details like specific size of nails to connect structural members all the way through the piece of wood. The performance codes state that anything that passes the furnace test can be used in construction. The sheet metal surface fastener passed the code test. And things are getting worse. Currently, some lightweight truss floor and roof beams have web members and top and bottom chords connected with glue (fig. 9–4). There is a joke in the fire service that the next performance code change will allow builders to connect trusses together with strips of loop or hooked fabric fasteners.

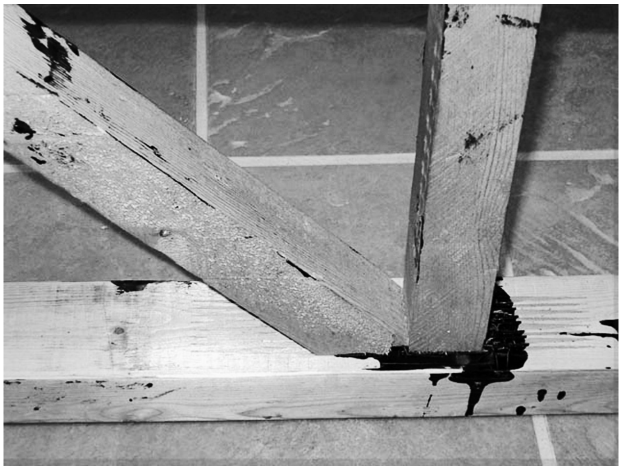


Fig. 9–4. A wood truss with glue connections.

The lightweight wood truss has also left a record of death and destruction in the fire service, from the East Coast to the West Coast. The following firefighters from across the country were killed by truss roof and floor collapses during fires:

- James Presnall (Irving, Texas, 1984)
- Todd Aldridge and Mark Benge (Orange County, Florida, 1988)
- Alan Michelson (Gillette, Wyoming, 1990)
- James Hill and Joseph Boswell (Memphis, Tennessee, 1993)
- Strawn Nutter (Louisville, Kentucky, 1994)
- John Hudgins and Frank Young (Chesapeake, Virginia, 1996)
- Edward Ramos (Branford, Connecticut, 1996)
- Brant Chesney (Forsythe County, Georgia, 1996)
- Garry Sanders, Brian Collins, and Phillip Dean (Lake Worth, Texas, 1999)
- Joseph Dupree (Los Angeles, 1999)
- Lewis Mayo and Kimberly Smith (Houston, 2000)
- John Ginocchetti and Tim Lynch (Manlius, New York, 2002)
- Cyril Fyfe and Kevin Olson (Yellowknife, Northwest Territories)

Of these 21 firefighters who died when trusses collapsed during fire, 6 (Alan Michelson, Brant Chesney, John Ginocchetti, Tim Lynch, Cyril Fyfe, and Kevin Olson) were working above the trusses. The majority (15) of the firefighters were operating below the trusses. Most of the firefighters were operating hose lines and pulling ceilings when caught and trapped by the truss collapse.

Open-Web Steel Bar Trusses

A lightweight steel truss is a long steel bar, bent at 90° angles and welded to angle irons at the top and bottom of the bar bends. The bent bar forming the web members can be as thin as a ½ inch in diameter. Thickness of the steel is an important factor in determining whether the truss will fail during a fire. For example, a thick steel bar truss can absorb more heat than a lightweight steel section. A thin steel bar truss can be heated to its failure temperature much faster. Increasing the mass of a steel structural element can increase its fire resistance to a limited degree. A massive, unprotected, solid steel I beam of sufficient thickness could even be given a one-hour fire resistance rating. If tested in a furnace by means of the time-temperature curve—and if the unprotected steel absorbed sufficient heat to prevent the column's cross-sectional area from reaching an average of 1,000°F (or of any one location reaching 1,200°F within that time)—the large solid steel member could be give a one-hour fire rating.

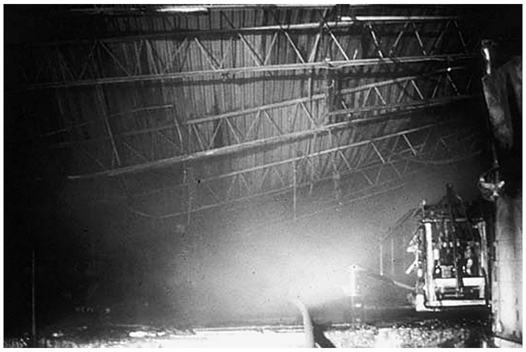


Fig. 9–5. The World Trade Center floor supports were 60-foot open-web bar joists.

Fire testing has shown that unprotected lightweight steel bar trusses can fail after only 5–10 minutes of exposure to flame and heat. Floor and roof construction using steel bar truss joists (e.g., see fig. 9–5) have to be considered substandard by the fire protection community when compared to solid wood beams. This quick failure time during fire makes the bar truss inferior from a fire protection point of view. Unfortunately, the trend in building construction is toward the use of lightweight steel bar trusses.

On September 11, 2001, over 2,700 people, including 343 New York City firefighters, were killed when the World Trade Center collapsed. The two towers, built using lightweight steel truss floors, collapsed quickly. Once the collapse started, the South Tower's 110 floors of lightweight steel truss construction collapsed to the street in a cloud of dust within 10 seconds. The North Tower, also 110 floors of lightweight steel truss floors, "pancaked" down in 8 seconds.

On March 10, 1941, 13 Brockton, Massachusetts, firefighters were crushed to death in the balcony of the Strand Theater when a hundred-foot-long steel truss roof collapsed. One reason why steel truss floors and roofs collapse during fire is that the fluffy spray used to fire protect the steel is either absent or ineffective. There was no protection on the steel truss of the Strand Theater.

The asbestos spray-on coating applied to the steel trusses used in the World Trade Center towers was considered by the Chief of the FDNY to be inferior to concrete encasement of steel. He listed the following problems with the fluffy spray-on used as fire protection at the World Trade Center:

1. Failure to prepare the steel for spray-on coating adhesion. Rust and dirt allowed spray-on fire-retarding coating to scale and fall away from steel during construction.
2. Poor or uneven application of the spray-on fire retarding was discovered during postfire investigations.
3. Variation of spray-on material during manufacture made it ineffective.
4. Lack of thoroughness in covering the steel during application was a problem.
5. Failure to replace spray-on material dislodged by other tradespeople performing work around the steel during the construction of the building.

Construction of the World Trade Center, by the Port Authority of New York, was begun in the 1970s. Moreover, the towers did not have to comply with the minimum requirements of the old or new building code. For example, the Port Authority did not install automatic sprinklers as requested by the FDNY. Many of the construction features used in the World Trade Center were performance code recommendations. The more restrictive, specification code recommendations were eliminated from the Twin Towers to make the building lighter and to speed up construction.

Early Identification of the Truss

The key to safe firefighting strategy in any type of truss-constructed building is early identification of the truss. Notify the incident commander when a timber truss, a lightweight wood truss, or an open-web steel bar truss is discovered when searching for fire, pulling ceilings, or cutting a roof vent. Once notified of the truss construction, the incident commander may take defensive actions.

Sometimes a truss roof can be identified when conducting a size-up of the fire building. There are three truss size-up indicators an incident commander may see from the command post:

- Rounded rooftop
- Large interior spaces without interior columns
- Large-area occupancies known to feature truss design (e.g., theaters, supermarkets, garages, churches, piers, auto dealerships, bowling alleys, and lumberyards)

The firefighters may not realize the seriousness of a fire when operating inside a burning bowstring, timber truss roof building. Consider the following situations:

- The large space created by the concave underside of a bowstring truss roof acts as a heat sink. This large space, created by the upper chord of the bowstring, allows large amounts of flame to build up above the heads of firefighters searching inside for fire. Firefighters may not realize the large amount of heat, smoke, and flame in the building, owing to this large space above their heads (fig. 9–6). The heat floats above the firefighters while it may be cool at the floor level inside the timber truss building.
- The fuel load is in the truss roof. The building may be vacant, or there may be an absence of combustible material inside, on the floor. However, with a timber truss roof, there will be the equivalent of a lumberyard of wood in the trusses above your head. When smoke fills up the roof space, the firefighters may not see the massive timber truss roof structure overhead.
- When there is a bowstring timber truss roof with a high roof, the incident commander may get conflicting radio reports from fire officers inside and outside about the amount of fire in the building. The firefighters inside may report little heat and fire, because the flames and heat are above their heads; they cannot sense the heat in the concave roof space above them. However, the firefighters on the roof will report heavy fire in the building, correctly gauging the amount of heat and flame burning through the roof deck and giving the more accurate size-up.

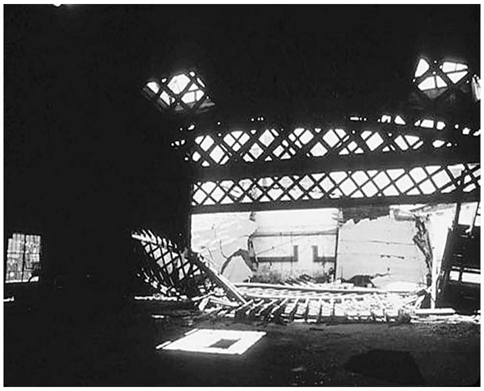


Fig. 9–6. There is a large space where heat and fire builds up in bowstring truss buildings.

The size-up by firefighters inside the building usually underestimates the fire. Firefighters searching inside a large-area timber truss garage for fire can be trapped by flashover that occurs above their heads. Four Chicago firefighters were killed in a garage with a truss roof when the fire flashed above while they were searching for the blaze. They could not escape the flashover fire and the eventual truss roof collapse.

Three Strategies for Firefighter Safety

To safeguard firefighters from further death and injury from any type of truss construction, incident commanders should use a threefold strategy:

1. ***Inspection.*** Firefighters must identify the existing buildings in the community that have truss construction. This can be done through a special or routine fire inspection program. Also, trusses can be identified while overhauling after a fire, when the ceiling is opened up to check for hidden fire. New truss construction can also be identified when plans for new buildings are filed; the local fire chief should be notified by planners and builders of all new construction.

2. ***Documented preplans.*** When the truss is identified in any kind of construction, that information should be incorporated into a fire preplan designed for the first responder. This preplan should be programmed into the dispatcher's computer. When a fire is reported in a building identified as having truss construction, this information should be transmitted by the fire dispatcher to responding firefighters over the apparatus radio or computer during the initial response to a fire, so they can take defensive actions.

3. ***Defensive firefighting.*** When prefire planning has been conducted, the documentation should include a defensive strategy for fighting truss construction fires. A recommended defensive strategy used by many fire departments is described in the following sections.

Contents fire

If on arrival the fire involves only the contents of the building—regardless of type of truss construction—use an aggressive interior hose line attack. As long as the flames do not involve the truss, there is little danger of truss collapse. Examples include wastepaper basket, stuffed chair, or mattress fires.

Structure fire

If on arrival fire involves the truss structure, use a defensive firefighting strategy. Remove any people from the house and attack the fire from outside. A fire involving the truss presents a collapse danger to firefighters. The truss may fail within 5–30 minutes after first firefighters arrive.

Defensive firefighting strategies

The key to safe firefighting operations at a truss building is early identification of the truss. Any firefighter discovering a truss should immediately notify the incident commander. Remember that firefighting hazard notification follows the chain of command. Firefighters discover hazards and report them up the chain of command, ultimately reaching the incident commander. Safety actions can be ordered only by the incident commander if he or she is notified of the hazard. Firefighters entering a burning building where truss construction is suspected should open up the ceiling and check the concealed space for the presence of trusses. When truss construction is identified, the incident commander not only must order firefighter operation above the trusses on the roof and the floor above but, most important, also must order the withdrawal of firefighters working inside the building.

Most firefighters who have been killed by collapsing truss roofs and floors were operating below the truss cave-in. The strategy at a truss structural fire is life safety first. Once fire enters the concealed spaces of a building with lightweight truss construction, fire spreads rapidly. The hidden flames can spread parallel to truss beams and also through the open web member. In other words, fire spread in the concealed space of a truss is 100% faster than in conventional solid beam construction. For example, the lightweight truss collapse that killed Todd Aldridge and Mark Benge in Orange County, Florida, occurred nine minutes after the first unit arrived. The incident commander should evacuate the occupants and firefighters when fire spreads to the concealed spaces and cannot be extinguished by the first hose stream.

Fire containment is a second priority of firefighting at a truss building fire, and property protection is the last priority. There should be no firefighters operating above or below the burning trusses. Protecting the adjoining buildings should be the strategy. Master streams should be used on the unoccupied fire building, and hose lines should be stretched into the adjoining buildings. There should be no roof venting of the fire building. The walls separating the buildings should be examined for fire spread. Close attention should be given to the cellars and the attic space of the adjoining buildings. The downwind building should be protected with interior hose lines first, then the upwind building. A thermal-imaging camera should be used to identify hot spots on the walls of adjoining buildings. All possible connecting concealed spaces should be checked for fire spread.

In summary, keep in mind the following key points about truss building fires:

- The key to safe firefighting operations at any type of truss construction is early identification of the truss and notification of the incident commander.
- Fire experience has shown that truss construction can fail within 9–30 minutes after arrival of the first companies.
- If the fire is a content fire, interior attack is the strategy.
- If the fire involves the truss structure and cannot be extinguished by the first hose line, a defensive strategy should be ordered.
- More firefighters operating hose lines and searching below the burning trusses are killed than firefighters operating on the roof.
- Firefighters are in danger of being killed by collapsing trusses if they operate inside the building below the truss or on top of the truss roof. They can also be killed by a truss collapse if they operate outside the building, and a collapsing truss roof can push out a wall on top of firefighters outside, operating around the perimeter of the building.
- Fire in the concealed space of a building containing truss construction spreads 100% faster than in the concealed space in conventional construction. Flames spread along the truss members and through the web members.
- There are certain fire size-up factors regarding truss roofs that can be misleading:
  - The building content may be noncombustible, or the building may be vacant and at first glance

have little content to burn. However, the main fuel load may be the wood truss structure above the firefighters, not the content. There is a *heat sink* effect during a fire in a bowstring truss roof. Fire and smoke fill up the large concave roof space created by the truss curve, and little heat and smoke is detected at floor level.

- There may be conflicting reports of fire size from firefighters operating above (who say the fire is large) and firefighters operating below (who say the fire is small) the truss. Again, this is due to the heat sink effect. The incident commander should consider the report from above to be the more accurate size-up.
- A parapet wall may conceal the shape of a bowstring truss. Only a firefighter assigned to operate on the roof can identify the truss roof shape.

The use of truss construction is increasing, as is the use of steel and wood lightweight trusses. Consequently, the trend will be an increase in the number of firefighters killed and injured because of collapses in truss building fires. This sad fact will not change, so the fire service must change. We must change the way we fight fire. A defensive firefighting strategy must be used to fight fires in truss buildings. A veteran fire officer protested, "Chief, we cannot use defensive firefighting when a fire involves a truss structure as you recommend." My question to him was, "What would you say to me if you were the chief and a firefighter in your department was killed by a collapsing truss?" He did not have an answer. I did.

10 STAIRWAY AND HALLWAY FIRES

Paris: 15 people were killed in a high-rise project fire. Most bodies found in the stairway near the top floor. Clearwater, Florida (2005): 2 senior citizens died in the hallway of a high-rise apartment. Chicago (2004): 6 office workers killed in a smoke-filled stairway. New York City (1998): 4 people were killed in a smoke-filled stairway on the 27th floor during a high-rise apartment fire. New York City (1996): 2 people died in a stairwell of a city project, a high-intensity fire roared up a stair walls ceilings and floor; Ontario (1995): 6 people died in the smoke filled stairway of a high-rise apartment. New York: 1 firefighter killed in a dead-end hallway of a housing project. New York City: 3 firefighters killed in a stairway of a three-story row house. New York City: 3 firefighters killed in a hallway of a high-rise adult home.

Is there something wrong with stairway and hallway construction and design? Or is there something wrong with the way we use stairways and hallways during a fire (fig. 10–1)?

Fig. 10–1. Stairways and hallways are deadly during fires.

Case Study of a Stairway Fire

Responding to a fire in a five-story tenement building, as captain of an engine company, a quick size-up showed black smoke coming from a top-floor window. A woman could be seen leaning out the window below the pushing smoke, waving her arms and calling for help. I said to myself, this is a top-floor fire, and we better get the line up there. However, running up several steps to the entrance door, to the small vestibule, and about to push open the door to the hallway, I was met with flames behind the glass hall door. The entire first-floor hallway was in flames. This did not make sense. I was still thinking we had a top-floor apartment fire, and the woman was about to jump out the window. As soon as the hose line was charged, we started extinguishing flames in the hallway. Then, we started directing the hose line up the stairs. We moved to the second floor in the fire and smoke, made the turn, and then started up the stairs to the third floor. I began to sense that the heat had subsided, so I told the firefighter to shut down the hose line. The steam and smoke cleared up, and then we could see the hallway. There was no fire remaining in the stairs; the stair fire was extinguished. We quickly proceeded up the stairs to the woman's fifth-floor front apartment. The door to the apartment was still open, and the rooms contained no fire. The smoke coming out her window when we rolled up was coming from the stairway fire. She had opened her apartment door to check the hallway, was overcome by a blast, and had left her apartment door open. The ladder company had rescued the woman with the aerial ladder before we got there.

Several years later, as the battalion chief responding to an early-morning report of an odor of gas on the same street, I discovered how that fire started. The company officer searching the building for the odor of gas called on his portable radio, "Chief, wait there. I want to show you something." He came over to my car, carrying a five-gallon plastic container with a rag sticking out of an open top, and said, "I found this container of gasoline on the top floor of the public hallway near the bulkhead door leading to the roof. The rag sticking out of the bottle was partially burned." An arsonist placed the gasoline-filled container in the hall on the top-floor hall leading to the roof of the five-story tenement. The rag sticking out of the container was supposed to burn down to the gasoline. Then, the gasoline and the plastic container were supposed to burn and melt. The arsonist had hoped that as the plastic container sides melted down, it would slowly pour the flowing burning gasoline down the stairs. I realized how that stairway fire had started several years before.

Extinguishing Stairway Fires

On arrival, an incident commander may order for a hose team to extinguish a stairway fire. Flames may already be spreading three or four floors up a fully involved stairway. The stairway fire may have been caused by an arsonist using a flammable liquid (as in the earlier case study), or it may have started with combustible material stored in the stairwell. Also, a stairway fire can be caused by flames spreading from a burning apartment if the door is left open. If fire is coming out of an apartment, then close the door. This will prevent a cut off. In a vacant building or if the door is burned, the door sometimes may not be closeable.

The hose team must attack the apartment fire and have a backup line proceed up to extinguish the stairway fire. Whenever a fire threatens to cut off the hose team advancing up a stairway, the officer should call for a backup hose line. The officer in charge of the hose team fighting the stairway fire should wait for the backup line or leave a firefighter at the point where fire has been passed, to warn the advancing firefighters of any potential fire spread and cutoff. A fire officer should never allow the firefighters to pass fire when advancing up a stairway that threatens to cut off retreat. If the officer cannot accomplish the assigned task because of such a fire cutoff threat, the incident commander must be notified.

The primary life hazard at a stairway fire is the people trapped in the stair and hallways leading from the stair. At a stairway fire, people will be trapped in their apartments. Thus, ladders will be needed for rescue. When there is no rescue need, a portable ladder should still be positioned at a window opening onto the stairs. People, including firefighters, may need them for sudden escape. The aerial ladder should be used to place a firefighter on the roof to perform venting of the skylight and scuttle cover over the burning stairway. This venting keeps smoke and heat from spreading to top-floor apartments. The ladder may be repositioned for rescue and then returned to the roof for the firefighters.

Exterior fire spread will be from the stairway to the transoms from the stairway to rooms. Also, if there is a suspended ceiling, the fire may spread into the ceiling space and then into the apartments by way of air-conditioning vents. Furthermore, a fire venting out of a scuttle cover or skylight may spread to the common roof space through the "returns" of skylights or scuttle openings. Exterior fire spread can be autoexposure from windows on the fire floor to open windows above. If a stairway fire is not vented at roof level, it will quickly spread, first to the top-floor apartments and then to the apartments of successively lower floors.

The collapse danger is the stairs. If the stairway is made of wood, the stair treads may burn. If the stair treads are stone, they may crack and shatter. The entire section leading from one floor to another may collapse. A stair section can fail and collapse down on the lower stairs, causing a pancake collapse of several stair sections. Portable ladders should be used to span weakened stair sections. Acting as a roof ladder, the weight of firefighters will on the ladder spanning the floors, not the stairs. If a stairway fire is not extinguished, the stairs will become an inferno collapse. Then, people will jump to their deaths from windows.

A stairway or a hallway can be an area of refuge or a deadly space during a fire, depending on how it is used. Firefighters can retreat to the safety of a stairway with a hose line when the apartment fire spreads out to the hallway. If a firefighter searching a hallway becomes disoriented and trapped in a dead-end corridor (a hallway with no exit at the end), that can be fatal. Also, if firefighters go above a fire and fire spreads into the hallway from an apartment, they can be trapped.

People trying to escape a fire often attempt to go up a stairway to the roof for safety. There they are trapped by smoke and heat rising up the stairs (fig. 10–2). Hallways have become more dangerous for occupants and firefighters for several reasons; for example, standpipe outlets are

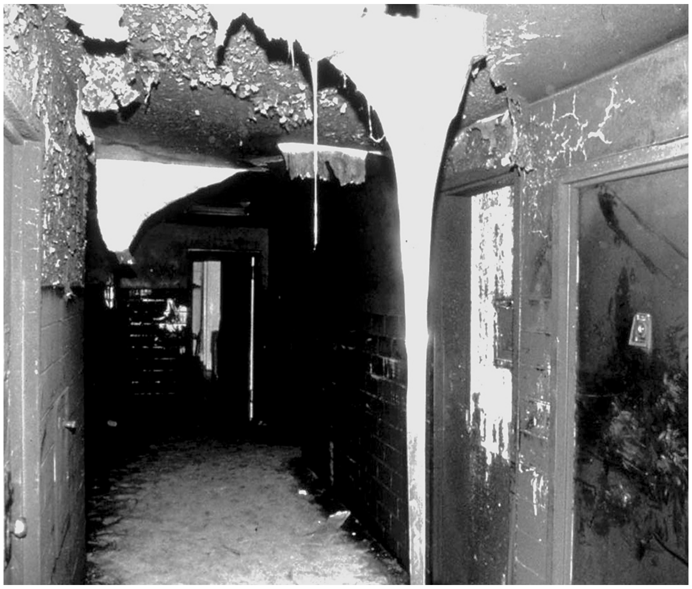


Fig. 10–2. Two people died in this New York City stairway fire.

being placed in hallways instead of enclosed stairways, and people and firefighters using these misplaced standpipe hose outlets can be overcome by smoke in the hallway.

Extinguishing Hallway Fires

Hallways in modern multiple dwellings are sealed spaces without windows to vent smoke. Modern high-rise apartments have HVAC duct systems connecting several floors of public hallways and corridors. If smoke spreads from a burning apartment to a hallway, it may then spread quickly to several floors above and below the floor of the apartment fire. Public hallways have dead-end corners and pockets in which occupants and firefighters can be trapped. Another reason halls are dangerous during a fire is that the self-closing mechanisms of apartments doors may have been dismantled by occupants (fig. 10–3). While this dismantled self-closing device keeps the residents from being locked out of their apartment, it allows smoke and heat to spread to the hallway if there is a fire in their apartment and they evacuate, leaving the door open behind them.

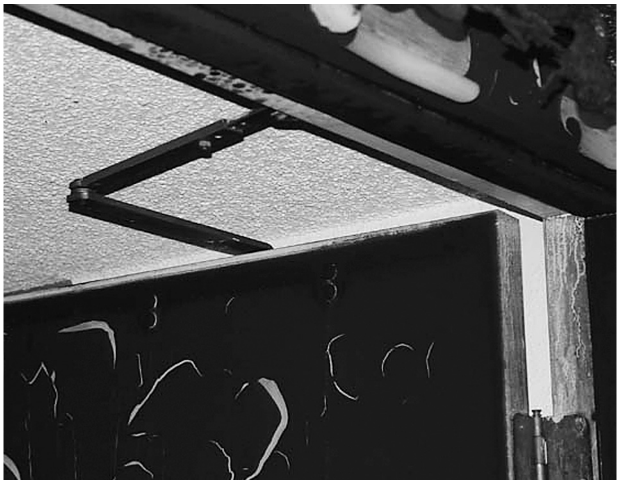


Fig. 10–3. The self-closing device on a door should automatically close the door.

Most people do not realize that in a fire-resistive high-rise building, it is safer to stay in an apartment or office than to try to escape. Stairways and hallways quickly fill up with deadly smoke during a fire. The firefighting strategy in a fire-resistive high-rise residence is to *defend in place*. That means that everyone stays in their apartments while the firefighters extinguish the blaze. The key to safety in stairways and hallways during a fire is for all apartment doors to be closed and all occupants to stay in their apartments (fig. 10–4). The apartments of a building are safer than smoke-filled hallways and stairways.

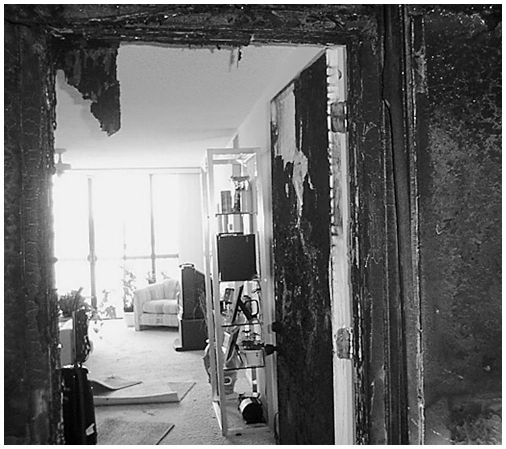


Fig. 10–4. A closed door is an important fire protection feature of a building.

Incident commanders must know how to use stairways and hallways for firefighting—including hose stretching, safe removal of occupants fleeing a fire, and venting smoke from a building. The following sections provide guidelines as to stairway and hallway firefighting strategy.

Forcible Entry and Stairs

Before forcing open a door to a multiple-dwelling building, the fire officers should first size up the hallway. Observe where the exit doors are located. Note the dead-end portions of the hallway. After the door to the burning apartment has been forced open, the hallway may fill up with smoke, and visibility quickly becomes zero. It is important to control the door leading from the public hallway to the burning apartment. Firefighters do not want the door to a fully involved apartment to swing all the way open and not be able to be closed again.

After a door lock has been forced and the door pushed open, heat and smoke will start to fill up the public hallway. When the door to the fire apartment is forced open, control it and quickly shut the door if there is too much fire in the apartment. After the door is open, if the apartment fire is serious, shut the apartment door and wait for the hose line before searching the apartment. If the fire is not severe, and heat and smoke allow a quick search before the arrival of the hose team, the officer should leave a firefighter at the apartment door to warn of fire buildup. Sometimes the firefighter at the door in the hallway may detect a buildup of fire and heat that the firefighters searching inside may not detect.

Stretching Hose in a Stairway

Firefighters must stretch sufficient hose up a stairway to reach a fire. Hallways in modern buildings are longer, and firefighters require more hose to reach a fire apartment. If the firefighters stretch preconnected hose to a house fire and use booster water, then there is very little chance of a hose-stretching mistake. However, if you respond to a fire in to a multiple-story building and you must stretch hose up a stairway and down a hallway, you must calculate the correct number of hose lengths to be stretched.

Generally, a veteran firefighter called a control firefighter or the pump operator will advise the firefighters as to how much hose to stretch. The strategy is to calculate the number of 50-foot hose lengths needed from the pumper to the building, from the first floor up the stairs to the fire floor and across the fire floor to the fire. There should not be too many hose lengths stretched, since this would increase the chances of kinked hose in the stairway, cutting off water to the nozzle. Remember the warning, “Kinks kill firefighters trapped by fire.” Even more important, there must not be too few lengths of hose stretched. The number-one criterion for firefighting to be successful is that there must be a sufficient number of hose lengths stretched up the stairs to reach the fire. *Stretching short*—that is, stretching insufficient hose up a stairway and not reaching a fire—is an unacceptable firefighting error. Stretching short has led to deaths, fire spread, and property damage. Calculating the correct number of hose lengths to be stretched up a stairway (not too many lengths and not too few lengths) is critically important to the overall strategy of the fire operation.

To estimate the hose stretch, you must first estimate the number of lengths from the pumper to the building. Then estimate the number of lengths required in the stairway to reach the fire floor; this is usually one length per floor, up to the fire floor. If the stairway has an open well and firefighters can stretch the hose up the opening in the center of the stairway, only one 50-foot length of hose will be required per four floors. Finally, calculate the number of lengths required on the fire floor in order to advance to the room of fire.

To reach a fire room in a private dwelling, you may need one 50-foot length. For a large apartment with partitions, you may need two lengths of hose to reach the last room and one length for the hallway. To advance a hose line in a high-rise or large office building, you may need four lengths.

For example, to stretch a hose up a stairway without an open well to a fire in an apartment on the fourth floor in a building one hundred feet from the nearest hydrant, firefighters would stretch two lengths to reach the building, three lengths to reach the fourth floor (one length to get to the second floor, another to get to the third floor, and a third to get to the fourth floor). To these five lengths would be added two more lengths to advance into the apartment and one for a long hallway. Thus, a total of eight lengths of hose would be required in order to stretch from the pumper to the fire.

Stretching Hose from a Standpipe

You would not use a hose from a standpipe to extinguish a stairway fire. You would use a standpipe hose line at a hallway or apartment fire. When using a standpipe outlet to connect fire department hose, firefighters are advised to carry four rolled-up lengths of hose and a nozzle up a stairway and connect the hose to the standpipe outlet on the floor below the fire, not the outlet on the fire floor (fig. 10–5).

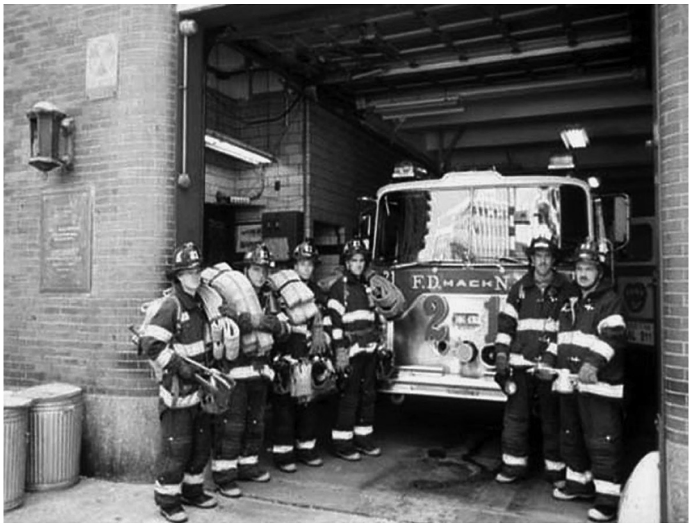


Fig. 10–5. Standpipe hose stretching requires four lengths of hose.

Standpipe outlets are erroneously placed in the public hallways of modern buildings, instead of in the two-hour-protected enclosed stairways. This is an example of poor fire protection design by architects and poor inspection and oversight by the fire service. Architects are responsible for fire protection design; however the fire department inspectors must control new construction and design for fire protection.

An incident commander should not order firefighters to connect a hose line to a standpipe outlet that is located in the public hallway on the same floor as the fire apartment. Firefighters advancing the first attack hose line should connect to the standpipe outlet on the floor below the fire. After all the hose lengths are connected together, then stretch up the stairs to the fire floor from the floor below and advance down the hallway to the fire apartment. Subsequently, if flames from the fire sweep out of the apartment and into the public hallway, firefighters can retreat down the hallway to the stairway enclosure. Firefighters can back down several steps and continue to discharge water into the hallway and regroup.

Firefighters can then advance out of the stair enclosure down the hall to the apartment again when fresh firefighters become available. The water pressure and volume supplied to the attack hose line can be safely controlled by a firefighter from the standpipe outlet from the floor below the fire. Also, if there is too much fire in the hallway, firefighters directing the hose stream can maintain a defensive position in the stairway. If the attack hose line was connected to the standpipe in the public hallway on the same floor as the fire, flames coming out the apartment door could force firefighters to abandon the hose line owing to spreading fire and heat. Flames also could burn the hose off the standpipe outlet and possibly trap smoke-disoriented firefighters in the hallway. It is safer to connect hose to a standpipe outlet on the floor below (fig. 10–6).

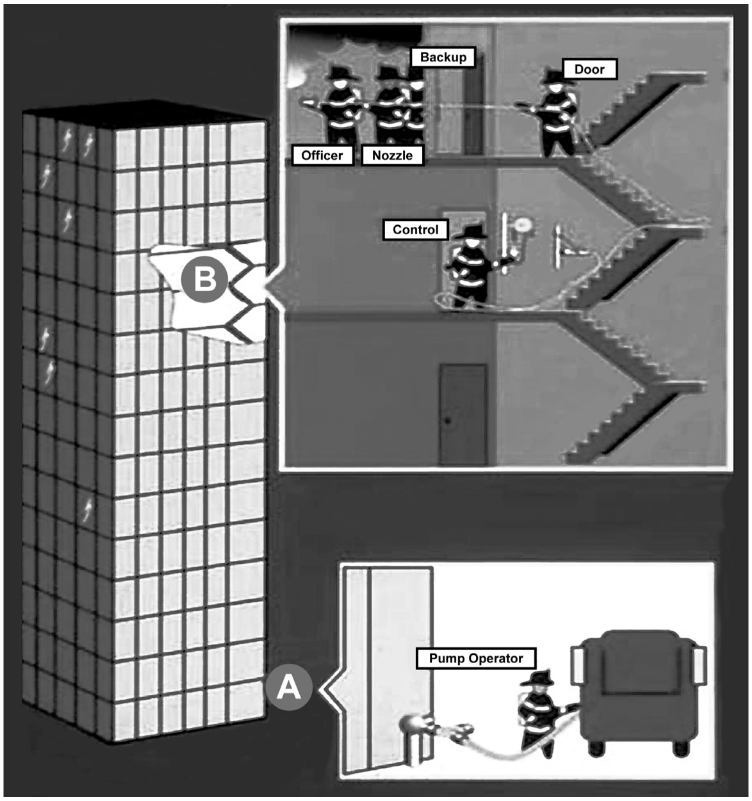


Fig. 10–6. Connect a hose line to the standpipe on the floor below the fire.

One-Stairway Buildings

In multiple-dwelling buildings that are several stories high and have one stairway, the firefighters must attempt to protect the hallway. This is why the first line goes up the interior stairway and not through a window. People are expected to stay in their apartments even if the building is not fire-resistive construction.

During a fire in a single apartment, people are safer if they stay in their apartment during the fire attack. The first line goes up the interior stairway, and firefighters attempt to extinguish the apartment fire. The windows of the apartment are vented as the hose team attempts to extinguish the fire before too much smoke fills up the stairway.

Simultaneously, the single stairway must be vented at the top by a firefighter who has gained access to the roof. Access to a roof can be obtained by crossing over from an adjoining building or by placing a ladder on the roof. The skylight over the stairway is vented, and the door leading to the stair roof enclosure is opened. This roof venting of a stairway prevents heat and smoke from banking out on the top floor.

Two-Stairway Buildings

As soon as possible after arrival at a serious fire in a building with two stairways, the incident commander must determine a stairway strategy. The stairways are divided up for different uses. Which stairway will be used for stretching the hose lines to attack the fire, and which stairway will be used for occupant evacuation?

The stairway used to attack the fire should not be used for evacuation because it will be filled up with smoke and heat. When the firefighters open the door to attack the fire, smoke and heat flow out over their heads. This can fill up the stairway if it takes a long time to extinguish the fire, or it can stop people on the floors above from being evacuated down that stairway. There should be no smoke in the designated evacuation stairway. The door from the evacuation stairway to the fire area should never be opened during the fire attack (fig. 10–7).

Firefighters use the designated evacuation stairway to ascend above the fire floor and search for trapped people. During a fire if people must be ordered to leave the vicinity of the blaze, they should be directed to go down the designated evacuation stairway. When a building has a standpipe hose system, the stairway with the standpipe outlet will be used to attack the fire. In some buildings, one of the stairways will be smoke proof. If present, the smoke-proof stairway, also called the fire tower, should be used for evacuating people from floors above the fire. Firefighters must keep the attack stair door open, to stretch a hose from the standpipe to the fire. As a result, smoke and heat rise up the attack stairway. If there is a door from the burning apartment that opens onto the designated evacuation stairway, it should not be opened. This door should be kept closed, so that the stairway is kept smoke free.

Dividing up stairways for fire attack and evacuation is easier said than done (fig. 10–8). To do this, there must be a public-address system in the building, allowing the fire chief to speak to the people trapped above the fire. If there is no public-address system, there can be no organized movement of people in the burning building. People not knowing what to do may attempt to escape the fire—tragically leaving a safe apartment and entering a deadly smoke-filled hallway or stairway.

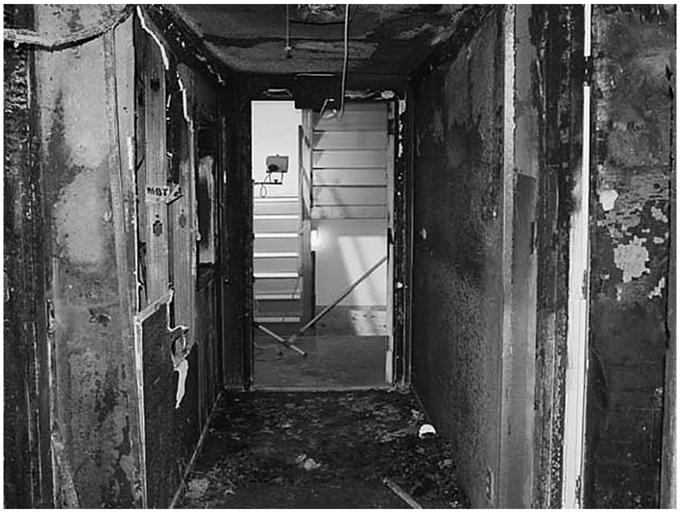


Fig. 10–7. This stairway was designated the evacuation stairway, and the door was closed.

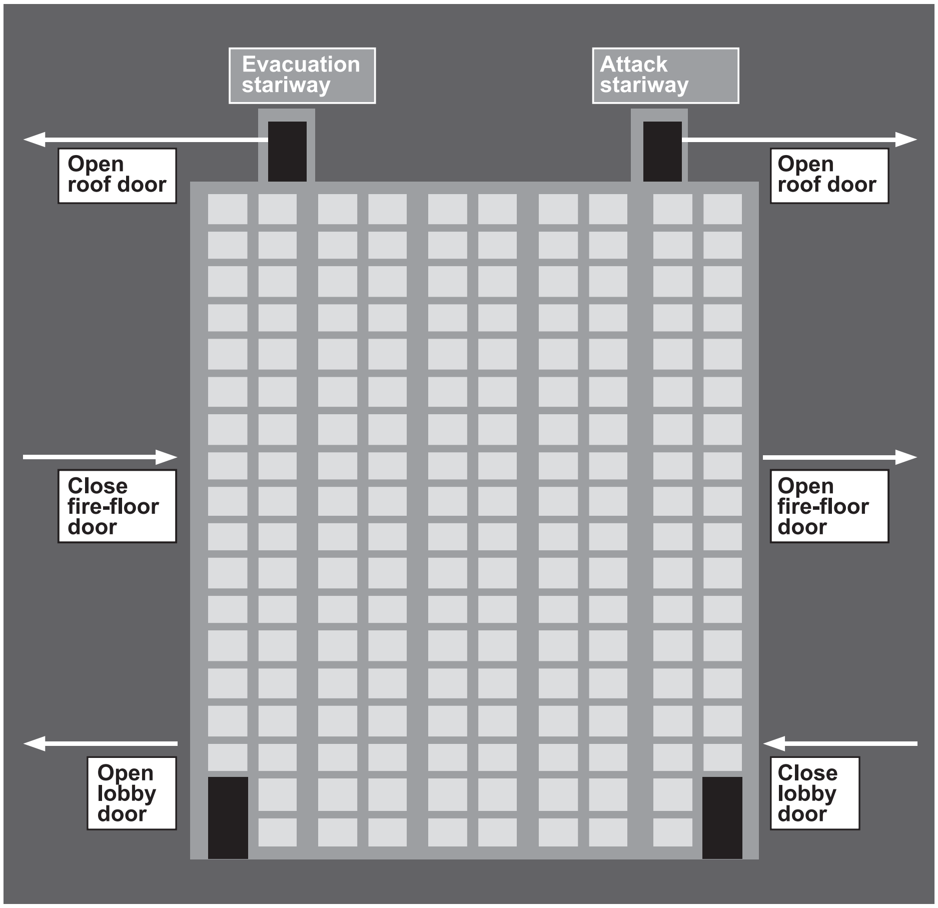

Evacuation stairway
Attack stairway
Open roof door
Open roof door
Close fire-floor door
Open fire-floor door
Open lobby door
Close lobby door

Fig. 10–8. Divide stairs for fire attack and evacuation.

Fire Deaths

People who attempt to escape a fire are discovered dead or overcome in stairways and hall landings above their apartments or places of work. Notably, they are attempting to go above the fire, instead of below the fire. People mistakenly go to the roof of the building, seeking safety, and die in the stairs.

Many occupants of high-rise apartments erroneously believe that they should escape a fire by going up a stairway to the roof, where a helicopter may save them. This deadly misconception is due to seeing helicopter rescues on television during floods and some high-rise fires. Occupants of a high-rise building should never go up a stairway to the roof during a fire. Smoke and deadly gas, not safety, will await at the top of the stairs. The stairs quickly fill with smoke at the top floor if the roof door and skylight are not opened.

Also, many stairs do not go to the roof. They may dead end at a lower floor. Other stairs terminate on top floors and have ladders or locked hatch covers that cannot be opened. Other stairways lead to a mechanical machinery room.

Furthermore, helicopters cannot land on the rooftops of most buildings in the United States. Smoke and reduced visibility can keep aircraft away from the roof of a burning building. Heat and smoke can stall a helicopter engine. Even if people were taken off a roof, it would take hours to remove just a few of them. They would be swinging from the end of a cable, which may present more danger than the fire in the building. Only two or three people could be removed before the helicopter would have to take them to ground level; returning up to the roof could take approximately one hour, and most fires are extinguished within this time.

Helicopter rescue is a fast-growing urban myth. This myth is another reason why people are dying in smoke-filled stairways of buildings. Stairways and hallways can be deadly spaces. After a fire, all stairs from the fire floor level up to the roof must be searched.

Stair Venting

Most low-rise buildings have only one stair enclosure. In such an ordinary-constructed building, this single stairway sometimes must be used to attack the fire, to vent the fire, and if the fire cannot be extinguished, to evacuate occupants after closing the door to the fire apartment. This stairway, which will be used to attack the apartment fire, must immediately be vented at the roof skylight or scuttle over the stairs, to prevent buildup of smoke on the top floor.

When firefighters open an apartment door to advance a hose to the fire, smoke and heat flow out the open door and up the stairs. Smoke and heat can fill up the entire stairway. People above the fire are expected to stay in their apartments. If the stairway is not vented at the roof, smoke buildup will mushroom out on the top floor. This smoke can asphyxiate people in top-floor apartments and offices.

If people are already coming down a stairway before the hose team attacks the fire, firefighters should delay the fire attack. Opening the door to the fire apartment would allow fire, smoke, and heat to enter the stairway, trapping the people descending the stairs. However, as soon as the stairway is cleared of descending people, the door should be opened and the fire attack should be started. It is critically important that the smoke-filled stairway should be vented at the roof level. If occupants must be evacuated from the burning building during firefighting, the strategy is to evacuate the building occupants, by way of fire escapes and fire department ladders, not the interior stairway.

Nonattack Fire Strategy

It is possible that during a fire in a fire-resistive building, flames and smoke could be beyond control of the local fire company on arrival. People in a panic could already be filling the stairways and hallways, trying to escape the fire. In this situation, the strategy would be to not attack the fire but evacuate all the occupants. This would also be the strategy if the occupants on the fire floor had already been evacuated and people trapped above the fire were coming down all the stairs attempting to escape a fire. In this instance, the incident commander's strategy might be to not attack the fire. Instead, keep all doors closed to protect people descending the stairs (fig. 10–9). In this instance, all stairways would be temporarily used by firefighters to evacuate people from floors above the fire.

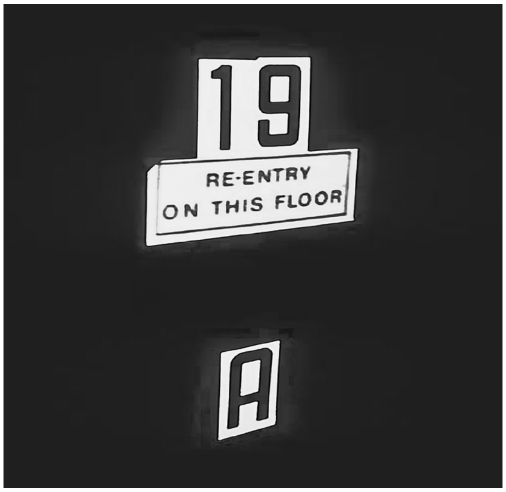


Fig. 10–9. Close the door to the fire when people are descending the stairs.

Stair doors leading to the fire apartment, smoke-filled hallways, or office occupancy would be kept closed. This strategy confines the fire and prevents smoke from entering stairways and trapping large numbers of people above the fire. Firefighters would assist in evacuating people from the floors above past the fire floor within all stair enclosures. As soon as conditions permit and sufficient resources arrive and the stairway is free of people, the door from the stairway would be opened and the hose line would be advanced to attack the fire. This strategy is in compliance with the principle of protecting life safety first, instituting fire containment second, and considering property protection third.

The key to stairway and hallway safety is to close the doors to the burning areas. A self-closing spring device must be installed on every apartment and kept in working order. This is the key to stairway and hallway safety.

Again it must be stated that in a non-fire-resistive building, during the initial stages of fire attack, people should stay in their apartments. The apartments are safer than the stairways and hallways. In a fire-resistive building, it is best for all apartment doors to be closed and all occupants to stay in their apartments. The strategy in a fire-resistive apartment building should be a total defend-in-place strategy. The apartments of a fire-resistive building are safer than a smoke-filled hallway or stairway.

High-Intensity Stairway Fires

New York City high-rise housing projects have experienced several so-called high-intensity fires in stairways. These fires could also be classified as flameover fires. A flameover fire is described by the National Institute of Standards and Technology (NIST) as a fire that rapidly spreads along the surface of a wall, ceiling, or floor (fig. 10–10). A flameover fire was first reported at the Winecoff Hotel fire, in Atlanta, in

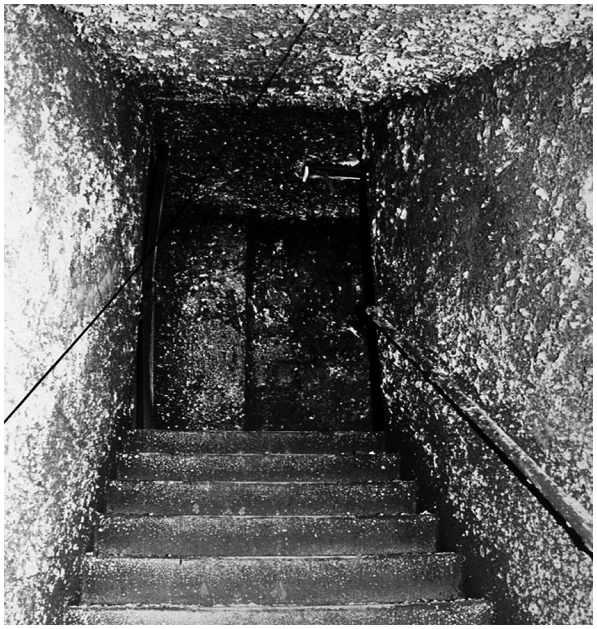


Fig. 10–10. This hall became an inferno as the paint on the walls ceilings and floor spread fire.

1946, where 119 people died in the upper-floor rooms. They were trapped in their rooms, and some jumped from windows because the stairs in the high-rise hotel were cut off by fire.

Recently, in New York City high-rise apartments, small rubbish fires in stairways have developed into rapidly spreading wall ceiling and floor flameover fires racing up 10–20 floors. This type of stair fire is caused by the buildup of many coats of oil-based paint on the stairs, ceiling, and walls over the years. This paint buildup resulted from frequent painting to remove graffiti. This combustible paint buildup allowed the flames to rapidly spread up the stairs in flameover-type fires. The paint buildup is being removed by the housing authority to reduce the danger of flameover fire.

Dead-End Hallways

A dead-end hallway is a corridor extension that goes beyond the exit door. It is a pocket in which a person may be trapped during an escape from a smoky fire. Smoke filling up a hallway can disorient occupants and cause them to be trapped during a fire. If disoriented in a smoke-filled hall and crawling past an exit door, they will be trapped in a dead-end portion of the hallway. This is another reason halls are dangerous places during fires. Occupants should be instructed to stay in their apartments during a fire and not attempt to enter a hallway or stairway, since it may fill up with deadly smoke.

Conclusion

In summary, there are four key points in stairway and hallway firefighting:

- Most low-rise buildings have only one stair enclosure. This stairway must be used to attack the fire. During most fires, people may safely remain in their apartments. However, if simultaneous fire attack and evacuation is necessary, people evacuated from above a fire must be assisted by firefighters, using fire escapes and fire department ladders to evacuate the building. If the fire cannot be extinguished, the door to the fire area should be closed, and the people above the fire should be evacuated down the stairway, past the fire. This stairway, which will be used to attack the apartment fire, must immediately be vented at the roof skylight or scuttle over the stairway, to prevent buildup of smoke on the top floor. People should stay in their apartments during the fire attack.
- Unfortunately, many people erroneously believe that the way to escape a fire in a high-rise building is to go to the roof and wait for helicopters. What actually happens is that they die in the stairway above the fire on their way up to the roof.
- Stairways and hallways can be deadly spaces during a fire. After a fire has been extinguished, firefighters must search all stairs from the fire floor up to the roof for victims.
- Apartment doors must be equipped with self-closing spring devices. All apartment doors must automatically shut. This is the most important life safety device in a high-rise apartment building. The key to stairway and hallway safety during a fire is to keep your door closed.

11 CELLAR FIRES

Cellars of commercial buildings should be protected with automatic sprinklers. Cellar firefighting has a high failure rate. Firefighting strategies for cellar fires are as follows: first, try a hose line attack; if that fails, set up indirect firefighting with cellar pipes and distributors on the first floor; if that fails owing to smoke and floor collapse dangers, call for high-expansion foam, and fill up the below-grade area; and finally, if that fails to control the fire, the last strategy is to use master streams, setting up the master stream around the building and protecting the nearby buildings. The incident commander must realize that the greatest life hazard at a cellar fire is the firefighter. While there may occupants living or working in a basement, there should not be in a cellar or subcellar.

Generally, a cellar has only one entrance stairway and few or no windows. Thus, there is limited access for hose line advance, and there are few opening for smoke ventilation. A cellar is an environment of deadly toxic carbon monoxide gas and explosion potential; only a subcellar presents more danger.

Sometimes the blaze that you think is in the cellar is actually burning one level below, in a subcellar. Access to a sub cellar can only be achieved by descending through a cellar. A basement has over half of its floor level above street level, whereas a cellar has more than half of its floor level below ground and is not considered a floor level when computing the height of the building; a subcellar is a floor level below a cellar and is sometimes found in commercial buildings.

Unless a cellar or subcellar fire is detected in the early stages, it is rare for an offensive hose line attack strategy to be successful (fig. 11–1). The incident commander must start thinking in terms of defensive firefighting as soon as the report of a cellar fire is received.

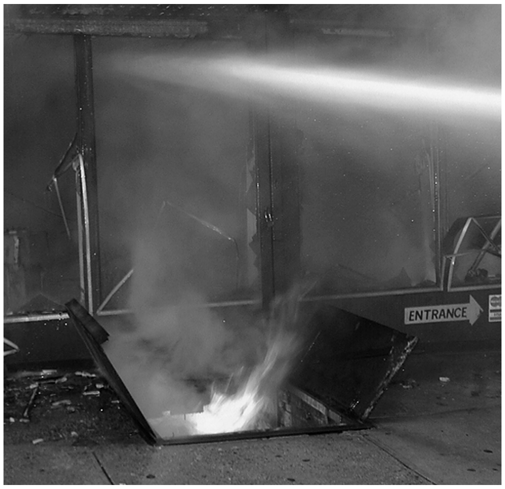


Fig. 11–1. Cellar firefighting has a high failure rate owing to danger, inaccessibility, and limited avenues for venting.

Hose Attack Strategy

First-arriving firefighters must attempt to take a hose line down into a burning cellar and extinguish the blaze. Smoke, heat, and flames rising from the cellar stairway may make this difficult or impossible. There may be only one entrance to a cellar; this single access area will be filled with smoke and heat, there is no alternative entrance. Thus, the key to extinguishing a cellar fire is the ability of the firefighters to move the hose line down the smoke-filled stairway. If the fire is localized and access down the stairs to the cellar is not too punishing, then the hose line will be advanced down the cellar, and the fire will be quickly extinguished. However, if the cellar stairway is filled with heat and flames and the hose stream cannot push this fire back down the cellar so that firefighters can descend the stairway, then the cellar fire will spread up through the building.

Some dangers to firefighters advancing the first attack hose line down into an outside sidewalk cellar stairway are falling down the stairs or becoming trapped in the cellar if the heat level has banked down to the floor and there is no clear space below the flames and smoke. Also, after several minutes in the cellar, if the fire cannot be found and extinguished, superheated gases flowing up out of the cellar entrance behind the firefighters can completely fill the cellar stairway. If the superheated gases turn to flames when mixed with air, the firefighters' only escape will be blocked, and they will be trapped in the burning cellar.

As the first attack hose team attempts to descend the cellar stairway, the incident commander should direct firefighters into both adjoining buildings' cellars to search for any openings or entrances between the buildings that could be used for hose line advance or through which fire might spread to the adjoining buildings. A second line should be stretched to back up the first attack hose line. Openings in the walls separating the burning cellar and the adjoining cellars may be used to advance hose lines into the burning cellar if the first attack hose team is not successful. Entrance into the burning cellar from an adjoining cellar will be on the same level and less punishing than advancing a hose line down a stairway into the path of rising smoke, heat, and flames.

Cellar Stairways

The design of a stairway greatly influences the success or failure of cellar firefighting strategy (fig. 11–2). A cellar stairway with a self-closing door at the

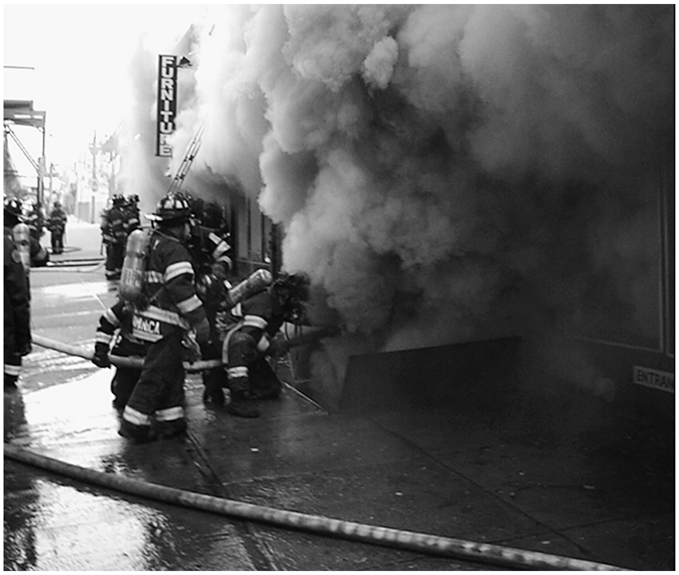


Fig. 11–2. Smoke and heat rise up into the faces of the firefighters attempting to descend a cellar stairway.

bottom of the stair enclosure will greatly increase the chance of successfully advancing a hose line and extinguishing a cellar fire; by contrast, a cellar stairway with a door at the top of the stair enclosure greatly increases the chance of failure in advancing a hose line down to a cellar and extinguishing a fire.

An enclosed stairway with a door at the bottom is the safest design for firefighting, because it allows firefighters to descend in a smoke- and heat-free environment. Firefighters descending cellar stairs of this kind can take the hose line down to the cellar through a smoke-free stair enclosure, start water in the hose, check their masks and safety equipment, and then slowly open the door to the cellar. They are already below the level of heat and flames banked down from the cellar ceiling. If the heat is banked down to the floor and there is no survivable area below the flames, or if the fire spreads beyond the ability of the hose team to extinguish it, the cellar door can be closed, and the firefighters can be safely withdrawn from the below-grade area. The attack hose team will still be inside a safe stair enclosure. Firefighters will not have to run through flames and heat while ascending the cellar stairs. The door at the bottom of the stair enclosure acts as a protective barrier for the firefighters, keeping the cellar stair enclosure free of deadly flames, heat, and smoke.

Residential Cellars

Some cellars in residential buildings are below grade at the front of the building but above grade at the sides and rear. It may be good strategy to take the first attack hose line through an alley to the rear of the building and attack the fire from this side. Access to the cellar from the same level will be less punishing at the side alley or rear yard. The cellar of such a building will also have many windows and several doors available to firefighters for ventilation. Excavation during the construction of the building may have created what appears to be a cellar at the front of the building but is actually at the same level grade at the sides and rear.

This type of partial-below-grade area may have occupants. Thus, life hazard will be a greater possibility, and searches must be conducted as soon as possible. If a fire occurs in this type of cellar, the incident commander should consider an initial hose line attack on the fire from a door at either side or the rear yard. From this approach, the firefighters will not have to descend a cellar stairway with smoke and heat blowing up at them, and the chance for successfully extinguishing the cellar fire will be greatly enhanced.

Reasons Why Interior Attack Strategy Fails

If firefighters are able to descend a cellar stairway and get below the heat barrier, they must then advance the hose line throughout the cellar to the seat of the fire. Storage materials such as boxes, cartons, packages, and furniture can make the hose line advance dangerous and difficult. This improper storage in a cellar creates dangers to firefighters advancing an attack line. It obstructs the reach of the hose stream, preventing water from hitting the flames, and the large stacks of storage conceal the exact point of fire origin. The safety factor provided by a hose stream reach of 30 or 50 feet is eliminated.

Another problem caused by storage in a cellar is collapse. When cardboard boxes stacked one on top of another are burning or are wet by a hose stream, they collapse.

If firefighters advance a hose stream through a narrow aisle between cardboard cartons and the cartons collapse behind them, they may become disoriented or trapped in the cellar. The hose line, used by firefighters to feel their way back to safety in a smoky cellar, will not be found if it is buried beneath a collapsing stock. Close supervision and control is necessary during a cellar fire to ensure firefighter safety. Firefighters who become separated from the hose line are sometimes discovered face down after a fire, drowning in the water-filled cellar after a fire.

Venting Cellar Fires

The strategy at a cellar fire is venting, venting, and more venting. Because there are so few areas of ventilation available to a cellar area, any type of venting must be conducted. The perimeter of the building should be searched for any doors or windows leading to the cellar.

Primary venting should be through cellar doors and windows, then doors and windows on the first floor. Subsequently, cut the floor on the first floor near a window to vent the cellar fire. In some instances, a vent opening on the first floor can be cut to provide smoke relief to firefighters in the hot smoky cellar. A floor vent opening should be cut at the opposite end of the floor area, away from the cellar entrance. Firefighters advancing a hose stream in the cellar must be able to push smoke and heat away from them.

If the cellar cannot be vented, the attack may not be successful. For example, at a strip mall fire, where the hose line is advanced from the outside cellar front entrance of the store, cut a hole in the first floor at the rear of the store. At some stores, advancing the hose line into the cellar requires stretching to the back of the store to an interior cellar stairway; once in the cellar, the firefighters advance hose to the front of the below-grade area. At this type of fire, cut the hole in the floor near the front of the store.

Positive-pressure venting by the use of fans can be successful at cellar fires when there are sufficient openings to push the smoke ahead of the advancing firefighters. Whenever positive-pressure ventilation is used to vent a below-grade area, the pressurized air will push smoke and, possibly, fire into adjoining cellar occupancies. Limited access and limited areas of ventilation in a cellar are reasons why the fire service requires that automatic sprinklers be installed in below-grade areas.

Cellar Pipes and Distributor Nozzles

If the initial hose attack fails, the next strategy is to place cellar pipes and distributor nozzles into use. Before using cellar pipes and distributors, the incident commander should order that the safety chief on the scene determine whether the first floor is stable and can support the weight of firefighters. Before the cellar pipe hole is cut in a floor, all doors and windows on the first floor should be opened to vent smoke. A hole should be cut in the floor as close as safely possible to the fire below—near a window if possible. Portable ladders should be placed over the cellar pipe openings. The portable ladder rungs support the cellar pipe and the hose that has been positioned into the floor opening.

Cutting an opening in the first floor of a commercial building for the use of a cellar pipe may be very difficult. Some wood floors on the first floor above a cellar are built up. When cutting a floor there may be several inches of masonry and one floor laid on top of the other. Over the decades and many renovations, an old building may have accumulated several layers of brick, concrete, and stone tile on top of a wood floor deck. For example, at one fire, while cutting a vent opening to a cellar, firefighters removed a half-inch tile, one a half inches of terrazzo floor covering (marble chips in cement), three inches of concrete, one level of brick, and one and a half inches of finished and unfinished floor deck.

To vent a cellar, firefighters may be able to prop open only one small cellar entrance door or cut a small hole in the first floor directly above the fire—and this takes time. If the first floor is constructed with brick, concrete, or terrazzo, it can be broken up and penetrated only by using heavy mauls and pneumatic jackhammers—which takes even more time. Cutting through several layers of masonry to introduce a cellar pipe will be very slow and very dangerous. The stability of the floor should be closely monitored.

Distributor nozzles that can be left in place and that do not require firefighters to remain in the store above the burning cellar should be used as the first strategy. The use of cellar pipes that require firefighters to direct the stream is a secondary strategy. Cellar pipes and distributor nozzles rarely extinguish cellar or subcellar fires. At best, setting up cellar pipes is a delaying tactic that allows time for the incident commander to set up a foam operation or a master stream as a defensive firefighting strategy.

Whenever cellar pipes are put in position, the incident commander should prepare for the next step, the use of high-expansion foam. Before the foam unit is set up, firefighters may have to barricade some of the windows or doors that were opened to vent the cellar during the interior attack effort. At the same time, the incident commander should consider positioning master streams as a final defensive firefighting strategy.

Flowing the Floor

Another delaying tactic that an incident commander can order during a change of firefighting strategy is the flooding of the floor above the cellar. Water from a hose stream may be directed into doorways or windows to spread across the first floor above an out-of-control cellar fire. Called flowing the floor, this strategy is used when the first floor becomes too dangerous for firefighters, owing to smoke or collapse. The objective of this tactic is to cover a porous floor in an old building with several inches of water, in the hope that the water will flow down any opening in the floor and slow down fire spread. It is used when firefighters have been withdrawn from the building and foam equipment or outside defensive streams have not yet been put into operation.

Floor Collapse

A cellar fire burning undetected for a prolonged time can destroy wood beams supporting the first floor, causing its collapse into the cellar. This hazard increases when masonry has been laid atop an old wood deck floor. A terrazzo floor—highly polished marble chips set in several inches of cement—is a type of first-floor surface that is found in restaurants, churches, office hallways, lobbies, and bathrooms. A terrazzo floor increases the dead load supported and can also conceal a cellar fire. Smoke and heat from the cellar fire will not rise up through the terrazzo floor as it will on a wood deck floor. The fire below may burn away the wood beams supporting the finished floor above without any visible sagging or the springy or spongy feel to the floor that would normally indicate collapse danger. After the wood beams are burned away, the floor load will be transferred to the terrazzo cement, and then there could be a sudden collapse of a large section of terrazzo floor into the burning cellar.

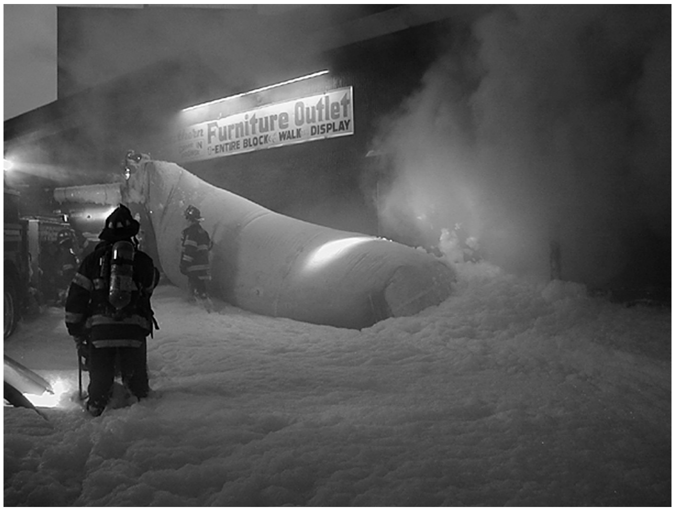


Fig. 11–3. Indirect attack with high-expansion foam will not extinguish a cellar fire, but will cool the cellar fire down so that firefighters with hose lines can enter a cellar for final extinguishment.

The presence of a first-floor terrazzo floor above a cellar fire should be considered a collapse danger. In some instances, a small amount of water from a hose stream sprayed across the terrazzo floor may evaporate quickly or turn to steam. This suggests that there is intense heat below that is being conducted up through the cement and marble chips. Twelve New York City firefighters died on October 17, 1966, when a large section of terrazzo floor they were standing on collapsed into a burning cellar fire at a drug store.

High-Expansion Foam

High-expansion (hi-ex) foam should be the next defensive strategy attempted if the cellar pipes and distributors do not successfully control the fire. Sufficient foam product must be available. Too many times, a foam operation is started before a sufficient amount of foam is available on the scene. Not only must the foam fill up the fire area, but the area must be maintained full of foam for a prolonged period of time.

A cellar fire may be controlled with hi-ex foam; however, it will not be extinguished (fig. 11–3). When used correctly, hi-ex foam can reduce 80% of the fire in the cellar. However, 20% of the fire will continue to burn. At a roaring cellar fire where hose teams cannot enter a below-grade level owing to heat, hi-ex foam can be introduced to the fire area; consequently, there will be an obvious reduction in heat and flames and an opportunity for the hose attack team to reenter the cellar.

The hi-ex foam will have to fill up the entire floor area and at least two-thirds of the cellar height before there is a reduction of fire and heat. As a result, heat and smoke flowing up the cellar stair will subside. That is when a hose attack team equipped with self-contained breathing apparatus (SCBA) may attempt another advance into the partially foam-filled cellar. Now the advancing hose team firefighters may be able to extinguish the remaining 20% of flames and heat left in the cellar.

Advancing a hose line into a cellar partially filled with foam is dangerous.

If air in a mask becomes depleted, you cannot continue to breathe for long periods when buried in foam. Firefighters walking in foam are susceptible to falling and becoming buried in foam, losing visibility, and becoming disoriented and lost in the cellar. Search ropes and portable radios are necessary to ensure the safety of firefighters advancing a hose stream in a hi-ex foam-filled cellar.

Certain preparations are necessary before hi-ex foam can be used against a cellar fire. Ensure that the opening at the side or rear of the cellar, through which foam could leak, is blocked with plastic, plywood, or whatever other material is available on the scene before starting to fill up the cellar with foam. This will conserve the amount of foam product used and will allow the spreading foam entering the cellar to control the fire more effectively. Also ensure that there is sufficient foam product on the scene for a long-term operation before introducing the foam to the cellar. The cellar must be maintained partially full of foam while the hose line operates. You do not want to run out of foam when firefighters are advancing a hose line into the cellar to extinguish the remaining fire.

Defensive Firefighting Strategy Using Master Streams

To direct a defensive cellar fire strategy, an incident commander must know how a cellar fire can spread upward in a multistory building of ordinary construction. If a cellar fire cannot be extinguished with interior hose streams, cellar pipes, or hi-ex foam, flames and large quantities of smoke will slowly spread upward throughout the entire building. These products of combustion originating in the cellar will rise up to the upper floors, through concealed spaces, stairs, elevator shafts, utility pipe openings, and air-conditioning ductwork. All vertical shafts will become chimneys for the cellar fire. All floors will be filled with deadly products of incomplete combustion, and the front of the building will be obscured with a cloud of smoke rising from the cellar fire. The fire will spread to the upper floors and eventually consume the entire building if not stopped.

If a cellar fire is burning in a multistory building that has adjoining structures on both sides, the first step of the defensive strategy is to ensure that the fire is confined to the building of origin and does not spread to exposures on the B, C, and D sides. Firefighters should be sent into adjoining buildings to search for any openings between the buildings through which fire may spread. This search should start in the cellars of the adjoining buildings and proceed on all floors above.

There may be openings in the party wall separating the burning cellar and the adjoining cellars. These openings might have been used to advance hose lines into the burning cellar and may now have to be closed. Any door that opens through party walls to adjoining exposures in the cellar and upper floors should be closed to prevent the spread of smoke and fire. The incident commander should be notified of the exact location of the door, and it should be requested that a hose line be stretched to this location. This hose line on an upper floor serves to prevent fire from burning through the door, rather than to advance a hose line.

When the defensive attack strategy is chosen, no interior attack strategy should be used. Using both defensive and offensive attack makes for a poor firefighting strategy. If there is a light or air shaft between the cellar fire building and an exposure building, the windows and or shutters opening onto the shafts should be closed, and the incident commander should be notified of the need for a protective hose line. Hose lines should be stretched to locations of possible fire spread in the exposure buildings, and the officer in charge of a hose team in an exposed building should keep the incident commander informed of the situation. If window openings onto shafts have protective steel shutters, these should be closed. Any flammable curtains and combustible materials nearby should be moved to a safe distance away from the window, hose lines should be ready, and the doors should be cooled down if necessary.

The top-floor ceilings in both adjoining buildings should be pulled down with pike poles, and the party wall separating the fire building should be exposed. Hose lines should be ready, and the walls should be examined closely for holes through which fire may spread. The presence of any openings—such as loose bricks, missing mortar, utility openings, and poke-through holes—should be reported to the command post. The incident commander should be told of the need for additional hose lines on the top floor to prevent fire spread through the party wall. All floors in exposure buildings should be continually examined throughout the entire defensive cellar firefighting operation.

While hose lines are being positioned in both connected buildings, aerial master streams should be positioned at the front and the rear of the burning building and supplied with water from large-diameter supply hose lines (fig. 11–4). Smoke may be the only product of combustion visible in the street. Smoke may be coming from every above-grade window at an uncontrolled cellar fire. Smoke flowing up the front and the rear of the building may obscure the entire structure. However, if master streams are not in position, fire will soon follow. If available, two master streams should be positioned at the front, and two aerial master streams should be positioned at the rear of the building. The apparatus should be positioned in flanking positions, and streams should be operated outside the collapse zone in case there is a wall collapse.

Defensive operations at a cellar fire will be for a long duration. If the cellar fire is not extinguished, flames will slowly consume all of the upper levels of the building. This may take several hours or several days depending on the size of the

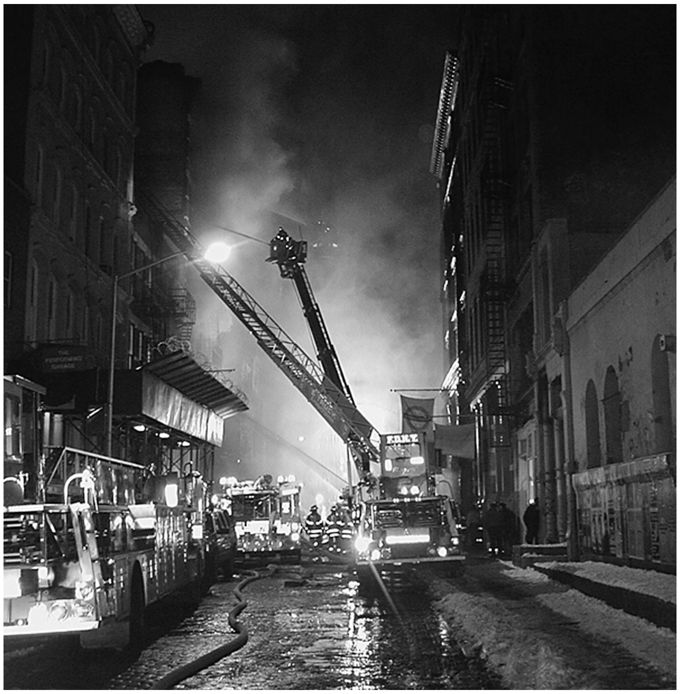


Fig. 11–4. Aerial master streams are the final strategy at a cellar fire that has spread to the upper floors.

building and how many master streams are available. The floors will eventually collapse. Furthermore, rubble buildup of the collapsed floor sections could create a lateral pressure against a front or rear wall and cause a collapse.

Salvage and Overhaul

After defensive master stream attack on a cellar fire that has spread to the upper floors, there should not be interior overhauling. It is too dangerous. The building has been destroyed by fire and pounded by master streams, and tons of water have been absorbed into the content and structure. However, if the safety chief declares the building safe enough for overhauling, the incident commander should consider the following actions.

First, ensure that all utilities—gas, electric, and water—are shut off. After extinguishing a cellar fire, even after utilities are shut off, a broken gas pipe may be leaking residual gas from a pipe that is not burning. If there is an odor of gas, the cellar area should be completely vented to prevent an explosion. Explosions have occurred in cellars from small amounts of residual gas, even after the gas supply was shut off. A flammable gas/air mixture confined to less than 25% of a room or cellar enclosure can cause an explosion. If a leaking broken gas pipe is discovered in a cellar, all firefighters should be withdrawn from the cellar, an explosive meter should be used to determine gas levels, and the cellar must be vented before firefighters reenter to perform overhaul.

During the performance of venting for overhauling operations, two openings are required in order to ventilate a below-grade cellar: one opening is for the elimination of smoke, and the other allows fresh air into the cellar. Positive-pressure ventilation with portable fans is effective in cellars. Ensure that the positive-pressure ventilation will not cause a fire flare-up. A fan should be used at one vent opening to exhaust cellar smoke while another fan introduces fresh air through another vent opening. If only one fan is available, it should be used to send fresh air into the cellar.

If there is a large amount of stock that could take several days to remove from the cellar, overhauling should not be attempted. Instead, a watch line should be posted around the clock, with a hose stream directed into the cellar. Such a fire will smolder for days.

After any cellar fire has been extinguished, it is not uncommon to discover several feet of water in a cellar. Water accumulation is a serious danger to firefighters overhauling in a below-grade area. A firefighter collapsing in a water-filled cellar will drown. A dewater operation using eductors may be necessary before overhauling is started.

Firefighters should be protected with SCBA before entering a cellar for overhaul operations. Asphyxiation deaths occur often at the beginning of the overhauling operation, when firefighters first enter the cellar. Even if there is little or no smoke, deadly, colorless, odorless, invisible carbon monoxide may be present. Carbon monoxide gas can be generated by a smoldering fire even after the flames have been extinguished.

An incident commander's strategy must be proactive from the start of a cellar fire operation. When the first attack hose team enters the cellar, the incident commander should already be considering the next move. Cellar pipes and distributors should be called for. The unit with high-expansion foam could be ordered to the scene and told to stand by. A survey of adjoining cellars and buildings should be performed, to identify avenues of potential fire spread. The adjoining cellars could be used to stretch a second hose line. Finally, the incident commander should evaluate all four sides of a cellar fire building for positioning of master streams for the final defensive operation.

12 APARTMENT FIRES

An apartment building is the largest structure in many suburban and rural communities. If a fire spreads to the common roof space, it will be a major-alarm fire that requires mutual aid. Hundreds of occupants will require relocation and temporary housing.

The initial firefighting strategy for apartment fires is to stop fire from spreading vertically to the large common roof space. The common roof space extends over the entire building, and if fire spreads to this area, it can spread over all sections of the apartment and lead to the destruction of the entire building. To prevent this, get a hose team above the fire and stop fire in the concealed spaces. However, if the initial strategy fails and if the flames spread to the common roof space, the strategy changes. The new strategy is to stop fire from spreading horizontally throughout the common roof space to the adjoining apartment sections.

Apartment buildings are ordinary (type III) construction four to six stories in height and are connected into two or more sections, or wings. The most common type of apartment building has two sections, and it is called an H-type building. The living units are generally located in the wings, and the elevators and a large entrance lobby are usually found in the central connecting part of the apartment building. This central area of the apartment building is referred to as the neck or the throat during firefighting radio communications.

Apartment buildings were first constructed during the 1920s and '30s in inner-city areas and the surrounding suburbs. Today they are present everywhere. The predecessor to the apartment building was the tenement house. (The word "tenement" is associated with turn-of-the-century inner-city poverty, crime, overcrowding, and urban decay and is no longer used to describe a multiple-dwelling building.) These large multiple-dwelling buildings present tremendous fire potential in the inner cities, surrounding suburbs, and some rural areas.

Construction

The apartment house has exterior walls of masonry. The floors, the roof, and the interior framing are partly or wholly wood. Steel columns and girders are sometimes used, and the steel I beams and girders are enclosed in plaster walls and create concealed spaces with the web section. The stairs and shafts have various degrees of fire-retarding protection.

Apartment buildings were built in wings that are each less than 3,000 square feet in area. One of the reasons for this subdivision into sections is that building codes require for concealed spaces over 3,000 square feet to be subdivided with fire-retarding partitions. The common roof space of an apartment building is a concealed space that is subdivided. However, in most apartment houses, the subdivisions are ineffective and allow fire to spread throughout the entire common roof area (fig. 12–1).

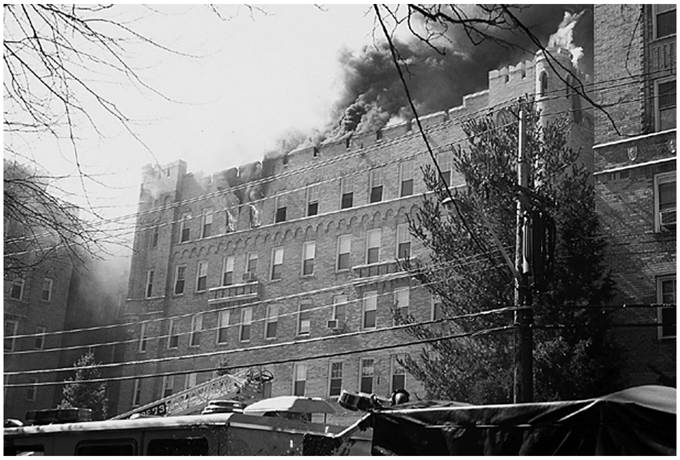


Fig. 12–1. A top-floor fire has spread to the common roof area of this apartment house.

The apartment building uses three structural elements for support:

- Masonry bearing walls
- Wood beam floors and roof
- Structural steel columns, beams, and girders connecting and supporting the large floor and roof sections of the building

The introduction of steel into apartment construction had several disadvantages. The steel framework was used in place of interior supporting brick bearing walls. Brick bearing walls stopped fire spread between sections. The steel columns and girders do not. Steel framework permits large-area residential buildings with many apartments and the coupling of several building sections to form large residential complexes. The structural steel used in apartment buildings poses three major concerns for the incident commander:

1. When heated by fire, steel columns twist, warp, sag, and fail to support a design load. An entire floor section may collapse if the steel columns fail.
2. Also, substantial elongation can occur in a steel beam. A steel I beam, 100 feet long, heated to 1,100°F, can expand 1 foot. This steel beam expansion can push out a wall.
3. Steel columns, generally in an I shape, can allow fire, smoke, and heat spread from the fire floor to the floors above. This steel column may extend from the first floor to the large roof space, and it is encased in plaster walls. When a fire burns through a ceiling or wall and spreads to the concealed spaces of the apartment building near a steel column, flames may extend vertically up the web section of the steel column, skipping several floors, and break out in the large common roof space. The steel column in an apartment house creates a fire spread hazard similar to the wall studs in wood frame balloon construction. Fire can quickly spread up to the attic space from any lower floor. The apartment building common roof space must be checked for fire spread even if the fire is on the first floor.

Common Roof Space

The major fire problem of an apartment building is the common roof space. The strategy of the incident commander is to prevent fire from spreading to the common roof space. The common roof space of an apartment house is a large, concealed void between the top-floor ceilings and the underside of the roof beams. It may extend over all sections of the apartment buildings. This space, not high enough to be called an attic, has no means of entry. When fire enters this space, it can spread out horizontally, over the entire apartment building, or worse yet, over several sections.

In some buildings, the common roof space is the size of a football field. This gigantic concealed roof space area is required by most building codes to be subdivided by fire-stopping. However, this fire-stopping is often imperfect and fails to restrict the fire spread throughout the common roof space (fig. 12–2).

Fire spread through a fire division may result from the several problems. The fire division between sections may not extend above the roof, and flames may spread over the top portion of the division wall. Alternatively, there may be loose bricks or holes in the wall owing to renovations for air-conditioning. In addition, plumbing or electric wire may have created openings.

Never trust a fire division in the common roof space of an apartment building. Open a ceiling on each side and check for fire spread. When the fire division is ineffective and fire spreads, the incident commander will have to send firefighters to open up the ceilings of top-floor apartments. Where fire is discovered, use hose streams to extinguish it.

The primary venting strategy at an apartment fire is to vent an apartment window to allow the attack hose team to advance and extinguish the apartment fire. Window venting can be accomplished from fire escapes or ladders. When there is a top-floor apartment fire or when flame has spread to the common roof space, to prevent horizontal fire spread, the primary venting strategy is to cut an opening in the roof over the fire. The objective in creating

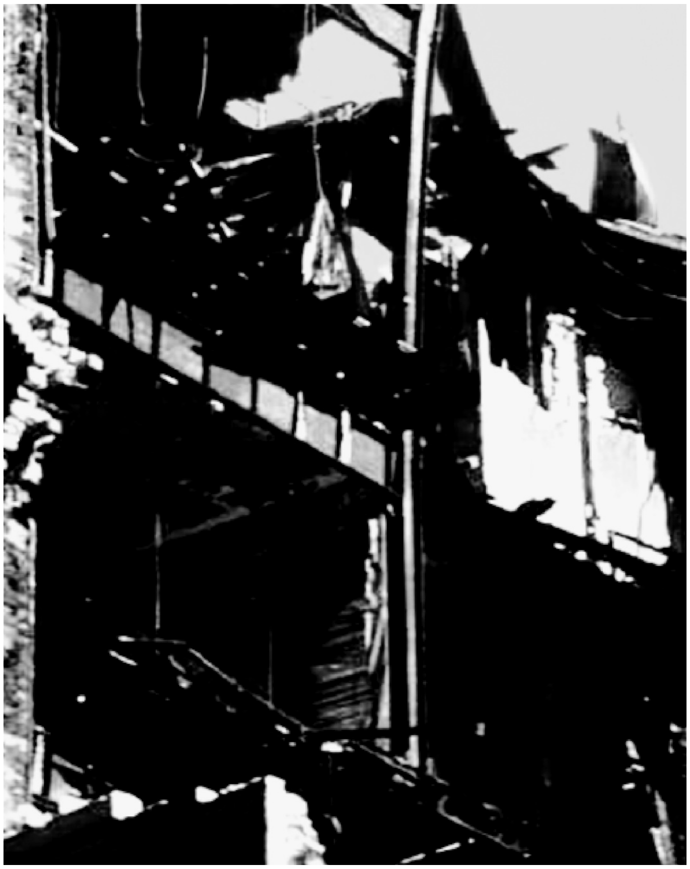


Fig. 12–2. The steel column allowed fire to spread to the common roof space and collapse during the fire.

this roof vent is to release heat and fire building up in the concealed space and slow the horizontal spread of fire.

If the fire spreads throughout much of the roof space, the damage to many of the apartments will be extensive. Water damage will be severe on the lower floors owing to the extensive use of water streams directed into the roof space. Experience has shown that when the common roof space of an apartment building is improperly fire-stopped at each section, the entire building can be destroyed by spreading fire (fig. 12–3).

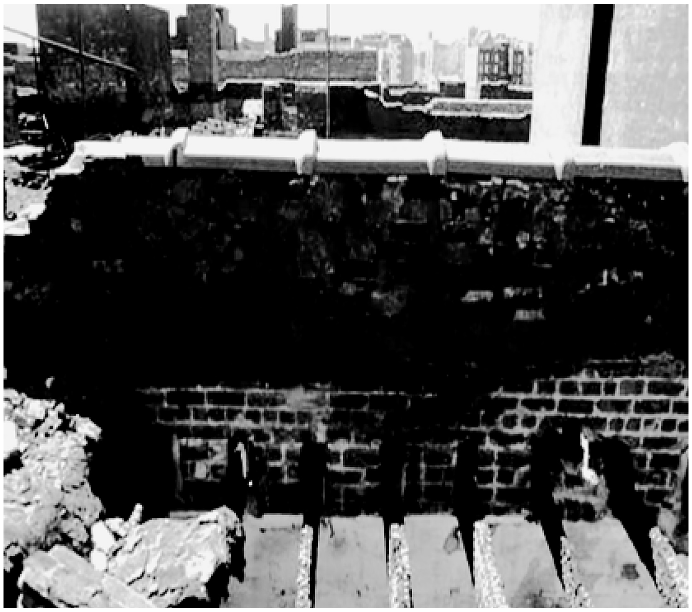


Fig. 12–3. Do not trust a fire division to stop fire spread. Fire spread through this wall, where the roof beams were back to back.

Furthermore, it is also been shown that most serious fires that damage large apartment houses are due to construction defects of the fire divisions in the common roof space, not by poor firefighting strategy. The fuel loading inside the common roof space of an apartment building is considerable. The common roof space usually contains roof beams, wood roof boards, wood furring framework for the ceiling below, wood lath backing for the plaster ceiling, and connecting wood bracing. Because this space has such large quantities of combustible materials and is tightly sealed, large amounts of combustible gases can accumulate during smoldering fire. Roof ventilation should be carried out once it has been determined that fire is in the roof space. One or more large (four foot by four foot) roof cuts over the fire can sometimes prevent a combustible gas buildup and thereby prevent horizontal fire spread.

Case Study

At a fire in a 5-story, fully occupied "H" type apartment house in the Bronx. The building had a frontage of 150 feet and was 100 feet deep. Fire was reported on the third floor in the "B" section of the two section "H" type building. When units arrived at the scene, they noted a moderate amount of smoke issuing from one window within the main entrance court, the throat section. This amount of smoke would usually indicate a medium fire. However, when units reached the fire apartment, they discovered that the apartment's entire six rooms were involved in fire. The first hose attack team attempted entry into the burning apartment. The back up second hose line was ordered stretched to the apartment on the floor above (fourth floor). A second alarm was transmitted. The firefighter from the first arriving ladder company on the roof discovered fire had already spread to the common roof space. The fire had passed the fifth floor and spread to the roof space by way of the web space in a steel "I" beam. A third alarm was sounded. The first battalion chief assigned as operations chief was directed to command the fire floor. When the second assigned battalion chief arrived, he was assigned to supervise roof operations already underway. All civilians were evacuated from the structure. A large opening was quickly cut in the roof over the fire. When this operation was completed and the fire was venting through the vent opening, there was a noticeable reduction in the horizontal spread of the fire in the common roof space. Hose lines were stretched to the fifth floor of the "B" wing and then to the top floor of the uninvolved section, the "A" wing as a precaution. This hose line in the "A" wing was positioned there to cut off any fire spreading to this section of the building through the common roof space. Ceilings were pulled, the roof space was examined, and fire was confined to the "B" section. Two additional hose lines were sent to the top floor of the "A" wing to stop the fire spread in the roof space.

During the initial stages of the fire, the first arriving aerial platform was placed directly in front of the fire building when it arrived on the scene. The bucket was raised and positioned in the throat of the building. This is standard operating procedures in the Bronx. The apparatus was supplied with water, and after firefighters were withdrawn from section "B" due to a partial collapse, the aerial master stream was directed at visible flames in the "B" section. A second tower ladder had been positioned in the rear and it too was ordered supplied and put into action. This aerial platform at the rear of the building was able to extinguish fire in the rear portions of the "B" section. Firefighters continued to operate in the uninvolved portion of the building, the "A" wing, top floor pulling ceilings and using hose streams preventing fire extension to this section of the building. The fire was declared under control one hour and 42 minutes after the initial alarm.

Strategy for Apartment Fires

Hose stretching

An offensive firefighting strategy in a large apartment building will require that many hose lines be stretched. The first hose line is stretched into the burning apartment. The second hose line is stretched as a backup and may be sent to the floor above to cut off vertical fire spread to the common roof space. At an apartment fire, many hose lines may be required, because there may be many rooms in each apartment and many apartments on each floor. If flames spread vertically, each apartment on each floor may require a hose line for extinguishment.

Only the first three hose lines can be stretched up the interior stairs. After three hose lines go up one stairway, it becomes clogged with hose. Alternative methods of stretching hose should be considered. To avoid hose congestion after three lines have been stretched up a stairway, hose lines should be stretched up aerial ladders or fire escapes. Hose lines can also be hoisted outside the building to the upper floors by firefighters lowering ropes from a stair window. With the nozzle and prestretched hose attached to the rope at street level, the hose can be quickly hauled up the outside of the building. The hose is hauled up the outside of the building to a window in the public hallway on the floor below the fire. This hose is then stretched up the interior stairway to the fire floor.

Training with hose-hauling rope is necessary to perfect this hose-stretching operation; however, when done properly, it has the following advantages. It reduces the chances of entangling the hose up a stairway. Sometimes, the stairway wraps around an elevator shaft. In this situation, stretching hose up the outside of the building considerably reduces the amount of hose needed for the overall operation. Most important, it reduces the time it takes for a unit to get water on the fire.

Hose line placement

Heat rises, so at a fire in an apartment building, flames and heat extend in a vertical direction. Fire can burn to the apartment above through a collapsing ceiling and up through a radiator pipe recess, bathroom water pipes, and electric wire conduits. The offensive attack comprises extinguishing the fire and stopping the vertical spread of fire to the apartment above. This is best accomplished by positioning hose lines in the fire apartment and the floor above as quickly as possible. If there is no fire spread to the floor above, this hose is sent back down to the fire floor. Because these buildings are so large and hose stretches so long, start a backup hose line as soon as possible. Primary venting constitutes removing the windows of the fire apartment, so that firefighters can move in and extinguish the blaze. However, if this is a top-floor apartment, the interior fire spread of flames will be upward through the concealed spaces, holes in ceilings, or the web space of a steel column reaching the roof space. The fire will spread into the common roof space and then extend horizontally.

Once fire enters the common roof space, the firefighting strategy changes. The strategy now is to stop horizontal fire spread in the common roof space before it reaches the adjoining wing(s). If fire is in the roof space, the venting strategy is to cut a roof vent over the fire apartment and push down the ceiling. This roof venting, together with one or more hose teams operating in the top-floor apartments, pulling ceilings and directing water into the burning roof space, will reduce the chances that the fire will spread to the adjoining wing.

Positioning ladders

The first-arriving company officer should position the ladder directly in front of the fire building if there is no one trapped at a window. The ladder bucket should be raised and placed at the center of the H-type structure, the so-called neck or throat of the apartment building. From this position, all the windows of both wings, including those at the inner throat section, can be reached for rescue or possible use of the aerial master stream. This is particularly important as the spread of fire can be extremely rapid, making the possibility of encountering a trapped occupant or firefighter very real. This ladder should be supplied with water in preparation for a defensive exterior attack on the fire, just in case the interior attack fails. This is a proactive strategy assuming the worse. A second ladder should be positioned on exposure B, C, or D of the apartment house, depending on the need for potential rescue and the location of the fire. A ground ladder should be placed at fire escapes to assist evacuation of occupants and hose stretches.

Sector officers

When transmitting greater alarms for fires in large apartment buildings, the officer in command should consider calling additional sector officers to cover critical areas of these large buildings. A sector officer is given a geographic location, the floor or the roof, to operate and a function, such as fire attack officer or roof vent officer or prevent-fire-extension officer.

A large H-type building is actually two connected buildings. A triple H is three buildings connected together. Because of the large size of these buildings, several sector officers would be needed to take command of a critical area of the fire. The exterior fire spread problem at an H-type apartment house must be considered the adjoining sections.

At a fire in a large apartment building with several sections, each section can be considered a separate building. For example, at a top-floor fire that extends into the cockloft, the operations sector officer would normally be assigned on the top floor of the building section where the fire originated to supervise the initial hose line attack. As incident commander, I would be at the command post, in the street in front of the fire building. I would assign a second sector officer to supervise the roof operations above the fire, where roof venting is taking place and a third sector chief to the top floor of the other section, to prevent fire spread. The third sector officer in the uninvolved portion of the H, together with a ladder and engine company, could start to examine the common roof space for any fire that might be spreading from the fire in the other sector. If indeed fire did extend by way of the common roof space to this area, early preparations should be made to stop the fire spread. Roof venting could be planned, and additional hose companies and firefighters with hooks to open up ceilings should be sent to the top floor of this section of the apartment building.

Roof venting for top-floor fires

Waging a successful battle against any top-floor fire in an apartment building requires an aggressive interior assault by first and second hose attack teams, combined with the equally effective window venting and roof ventilation of the burning apartment. Roof venting is not required for lower-floor fires when there is no sign of fire in the common roof space.

For any fire, roof venting proceeds as follows. First, skylights and the bulkhead door leading to the roof must be opened. Next, the windows of the fire apartment are vented as the hose team moves in on the fire. At 95% of the fires, this will allow firefighters to remain on the fire floor, prevent smoke and heat buildup on the top floor, and extinguish the blaze. If fire enters the roof space from the top-floor apartment, a large (four foot by four foot) opening must be cut over the main area of fire as soon as possible, and the ceiling must be pushed down. Several roof cuts may be required. This will relieve the apartments below and the roof space of smoke, flames, and heat. Because of the reduction of heat and smoke by venting, the hose attack team will quickly advance in the apartment and extinguish the fire.

Roof venting creates the necessary thermal updraft and stops the horizontal spread of fire on the top floor and fire extension to the large common roof space. If fire continues to spread horizontally after the roof is vented, a so-called trench roof cut can be considered. However, trench cuts are a defensive move, to be made only after the initial roof ventilation is completed and firefighters have failed to stop horizontal fire spread in the common roof space. The trench cut must not interfere with the creation of the thermal updraft produced by the roof venting. Do not cut a trench before cutting a vent over the fire. Hose lines must be positioned above and below the trench cut to stop the fire.

If fire spreads throughout the common roof space of a section of the H-type building, smoke and flames will bank down into the apartments. The same ceiling cracks, poke-through holes for pipes, and electric lights that allow fire and smoke to spread upward will allow fire and smoke to spread downward. Primary searches must be conducted in all top-floor apartments. Collapse of top-floor ceilings is a danger when large quantities of water are used in a common roof space to stop fire spread. As fire spreads throughout the common roof space and descends into apartments, firefighters will be using pike poles to open ceilings, and hose lines will attempt to contain the common roof space fire from the top-floor apartments.

Defensive strategy at H-type apartment buildings

After some time, if the interior hose attack on the common roof space fire from top-floor apartments is not successful, the incident commander may order the withdrawal of firefighters to a safe area and start a defensive strategy. Once the sector officer confirms that all firefighters have been withdrawn to safety, a defensive strategy using aerial master streams may be started (fig. 12–4). The incident commander must order all firefighters to the floor below, to the adjoining wing, or out of the building, depending on how long the master streams will be used. Ceiling collapse is a danger owing to water buildup. Multilevel floor collapse in an entire section may occur when steel columns buckle from the heat.

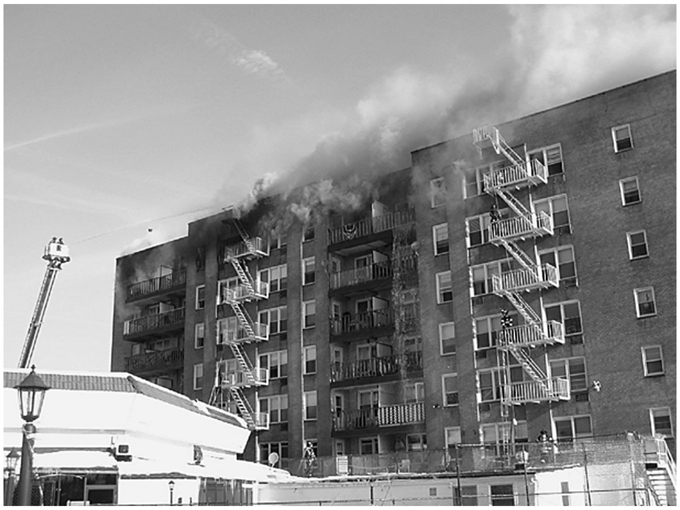


Fig. 12–4. Master streams are necessary for extinguishment when fire enters the common roof space.

Floor collapse may trigger a wall collapse. If the master stream is used for a quick knockdown, firefighters may be ordered to the floor below. If the master stream is to be used for a prolonged defensive attack, firefighters must be ordered to the adjoining sector or completely out of the building. The aerial master stream in the neck or throat area should be ready to operate in the top-floor apartments after the operations chief informs the incident commander that all firefighters have been moved to safety. Other aerial master streams prepositioned around the burning wing of the apartment building should also be used to extinguish the fire. When the initial hose line attack of a fire in a large H-type apartment building fails, the defensive fire attack will take hours before final extinguishment is reached.

A large H-type apartment building must be considered a target hazard. The many construction defects of a large apartment building allow fire to spread beyond the capabilities of most fire departments. These defects include concealed spaces; steel I beams; the large common roof space, which can spread fire over several apartments; and the fire division between building sections, which allows fire to spread from section to section.

Looking back on over four decades of firefighting, I consider the H-type apartment building fire to be the most difficult challenge after the high-rise fire. An incident commander should preplan firefighting strategies to combat fires at large apartment buildings. Mutual aid agreements must be updated as these burning large-area apartment buildings will overload the capabilities of most fire departments. Preplanning water supplies for several aerial master streams is an important part of the plan, as is planning and estimating the relocation and temporary housing needs of many families.

13 HIGH-RISE RESIDENCE FIRES

As the U.S. population ages, older citizens are moving into high-rise residences. Nursing homes and adult assisted-living residences are frequently housed in high-rise buildings, and the people living in high-rise residences, young and old, do not know how to react during a fire in such a building. All of these factors increase the strategy problems of fighting fires in high-rise residential buildings. While fires in "castles of commerce"—high-rise office buildings—get all the attention, the high-rise residences poses a major firefighting problem in this country.

The major reason why living and firefighting in high-rise residential buildings is more deadly is the lack of built-in fire protection (fig. 13–1). People living in a high-rise residence have very little fire protection designed into the buildings. When large numbers of people are housed in a high-rise building, there must be built-in fire protection systems to assist firefighters with manual firefighting. When you compare the high-rise residential building to the high-rise office building, you find a glaring lack of built-in fire protection.

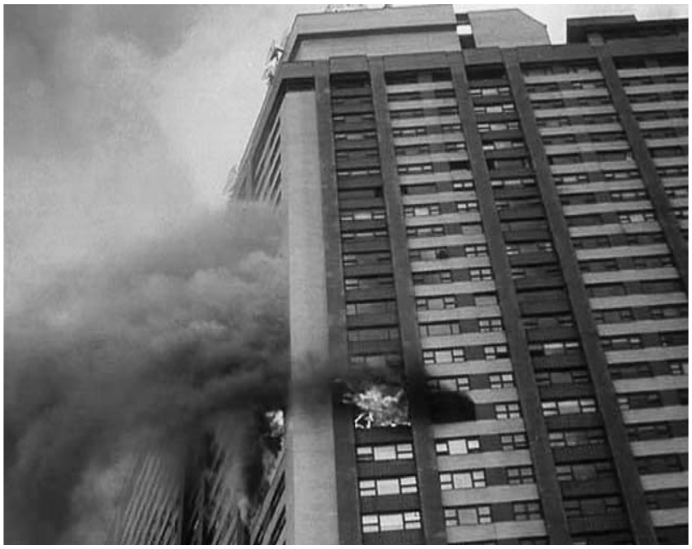


Fig. 13–1. Living in a high-rise residential building is more dangerous than working in a high-rise office building.

Sprinklers

Most high-rise office buildings in this country are equipped with automatic sprinklers throughout the entire building.

Sprinklers are more effective than firefighters using hose streams. In fact, firefighters cannot extinguish serious fires in high-rise office buildings. The firefighting strategy in large high-rise office floors is called *controlled burns*: the firefighters maintain control of the stairs, so that all the occupants above can escape, while all the contents of the floor burn out. Sprinkler protection—and partition walls to restrict the spread of fire in case the sprinklers fail—is the best fire protection. High-rise residential buildings have partitions walls separating apartments, but they rarely have sprinklers in the apartment. Hotels have automatic sprinklers in rooms, but only lately are we seeing high-rise residential buildings with automatic sprinklers in apartments.

Communications Systems

When a fire occurs in a high-rise residential building, the incident commander cannot give people trapped in apartments advice, because there is no communications system. In a high-rise office building, a public-address system is used to give instructions during the fire; a pubic-address system can transmit advice to people on all floors and in the hallways and stairways about when to leave and when to stay put. Unfortunately, there is generally no public-address system in a residential building, and hundreds of people will call the fire dispatcher, asking for help. There is no way for the incident commander to communicate with the people in the apartments—above, below, and on the fire floor—during a fire to tell them to stay there. There can be no lifesaving advice given by the fire officer.

Because of this lack of voice communications, people become isolated during a fire. They sometimes panic and make deadly mistakes, leaving their apartments and dying in a smoke-filled hallway or stairway. Residents may leave the safety of their apartments to descend a smoke-filled stairway, head up to the roof to wait in vain for helicopters and die in burning stairways above the fire, tie bedsheets together and climb down balconies only to fall to their deaths, panic and jump, open fire-resistive apartment doors and windows and die as smoke and fire fills up the rooms.

Evacuation Plans

There is great misinformation about what to do during a fire in a high-rise apartment building. People are supposed to stay in the apartment. Even if in the apartment adjoining the fire apartment, they should stay there. It is safer than the smoke-filled hallway. The building is supposed to be fire resistive, so the walls separating the apartments should resist fire for two hours.

Because there is no communications system, evacuation of people during a high-rise residence fire is usually chaotic. Some people leave, and others stay in apartments; still others even try to use the elevator during the fire. Some elderly individuals leave their apartments and are unable to make it down the stairs. They are found sitting in the stairs resting.

The strategy question for the incident commander at an apartment building fire is, should you evacuate the building during a fire, or should you tell the people to stay in their apartments? The evacuation strategy for a fire in a high-rise apartment building is no evacuation. After a fire in a high-rise residential building in which people have died in the stairways and hallways, the question asked by the lawyers will be, what were the instructions of the incident commander? The answer should be, "The strategy is to defend in place." That means everyone should stay in their apartment during a fire except the person(s) in the apartment that is on fire.

Firefighters extinguish the blaze while everyone stays in their apartments (fig. 13–2). If there were a communications systems in the building, the incident commander would tell the building manager to announce the following instructions over the voice system: "Everyone should remain in their apartments; keep doors and windows shut and turn off window air-conditioners if smoke is being drawn into the apartment through the air vent." The walls and doors of an apartment in a high-rise residence can resist fire for one to two hours.

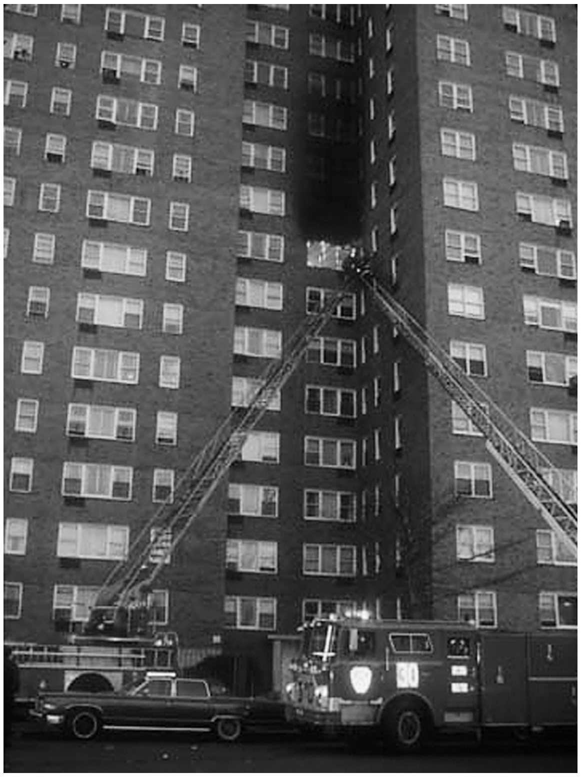


Fig. 13–2. The evacuation strategy during a fire in a high-rise residential building is for everyone to stay in their apartment except for the resident(s) of the apartment of fire origin.

To reiterate, the safest action for occupants during a high-rise residence fire is to stay in their apartments. Many people die in smoke-filled stairways and hallways during a fire. The local governments, the fire service, and the building management must do a better job of educating occupants of high-rise residential buildings about how to react in case of fire.

Standpipe Hose Hookup

Standpipe outlets in high-rise residential buildings have always been located in the enclosed stairway or the smoke-proof tower stairway. The stair enclosure door to the public hallway is kept closed while firefighters connect their hose and nozzle to the standpipe outlet on the floor below the fire. Firefighters can make a quick search of stairway above the fire for people descending from the floors above, as the stair door stays closed during the hose hookup.

When the hose hookup is completed and a check of the stairs above shows no descending occupants, firefighters stretch the hose up the stairway to the fire floor, open the door to the public hallway, advance the charged hose to the apartment on fire, open the apartment door, enter the apartment, and extinguish the blaze. When the standpipe outlet is located in the stair enclosure, it protects the firefighters during the hose hookup. However, in some new high-rise residential buildings, the location of this very important built-in fire protection equipment has been changed.

The standpipe outlets have been incorrectly relocated in the public hallway, instead of the enclosed stairway. This is poor design by someone unfamiliar with fire safety. Locating the standpipe outlet in a public hallway endangers occupants who may try to use this auxiliary fire protection equipment before the arrival of the fire department, and it endangers the firefighters who must use this equipment to extinguish fire. The crazy justification for locating standpipe outlets in the public hallway, instead of the enclosed stairway, is that the firefighters could connect the standpipe outlet in the public hallway, and the door to the public hallway would remain closed and the stair enclosure smoke free so that people could descend the stairway during the firefight. Evidently, the designer did not know or did not care how, if the door to the burning apartment is opened, smoke, heat, and flames come out and fill up the hallway. Moreover, the designer did not know that the people should not leave their apartments to evacuate the building during a fire. High-rise apartment buildings that have standpipes in the public hallway require that firefighters connect hose in a smoke- and heat-filled public hallway. In a fire, the public hallway would be an inferno, but the stairway would remain smoke free. This design of placing standpipe outlets in the public hallway is impractical.

Standpipe outlets have to be located in the stair enclosure. If a fire company arrives at a high-rise apartment fire and finds the standpipe outlet located in the public hallway, they should operate as follows: Do not connect to the standpipe in a public hallway on the same floor as the fire apartment. This public hallway could quickly fill up with smoke and heat if the fire apartment door is left opened. If the hall becomes filled with smoke and heat, this would force firefighters to abandon the hose and retreat to the stair enclosure. When discovering the standpipe outlet in the public hallway, firefighters must go to the floor below the fire and connect to the standpipe outlet in the public hallway on this level and stretch the hose up the stairway to the fire floor. Then, firefighters open the door to the public hallway and advance down the hall to the burning apartment.

Self-closing Apartment Doors

Most building codes require apartment doors in high-rise residential buildings to be equipped with self-closing devices (fig. 13–3). This device automatically closes the door after it is opened. This is an important, lifesaving piece equipment. A door in a high-rise residential building has a minimum fire resistance rating of one hour.

A self-closing door opened by a person fleeing a burning apartment confines the fire inside the apartment because the door automatically closes after the person leaves. The closed door to the fire apartment keeps the hallway free of smoke and heat. Also, the closed door protects neighbors in adjoining apartments who may or may not leave their apartments.

Unfortunately, a self-closing door sometimes accidentally locks a person out of his or her apartment, when picking up a delivery in the hallway outside the apartment. As a result, people sometimes purposely disable the self-closing device on their apartment door. Disabling the lifesaving self-closing device can lead to disaster. This is one of the main reasons people are dying in smoke-filled stairways and hallways during high-rise residential building fires. In 2005, this action contributed to two deaths in the smoke-filled hallways at a fire in the Dolphin Cove high-rise apartments, in Clearwater,

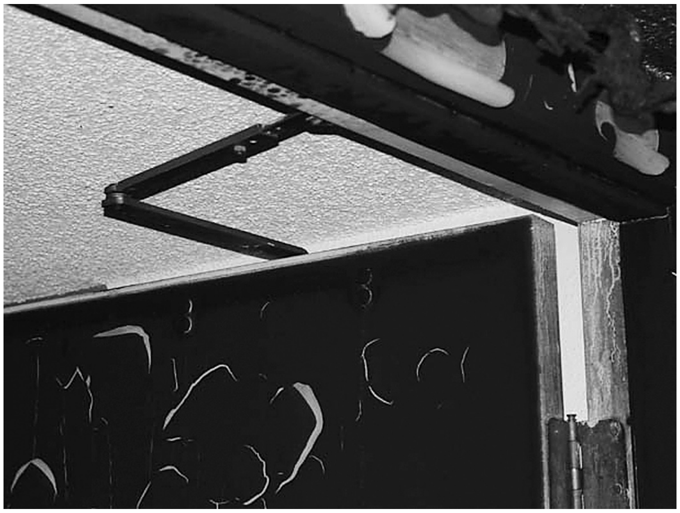


Fig. 13–3. A self-closing device should be on every door in a high-rise apartment building.

Florida. Many of the apartment doors had inoperative self-closing apartment doors. After the person fled the burning apartment, the door remained open, and the fire and smoke from the burning apartment spread quickly into the hallway where the people died. As the lifesaving fire education radio commercial says: Close the door! Close the door! Close the door! It can save your life during a fire.

Elevator Failure

During a fire in a 34-story New York City high-rise apartment building, three elevators failed. A firefighter was operating the elevator that took the first attack hose team to a floor below the fire. Operating on phase II firefighter service after discharging the firefighters, the firefighter operating the elevator started to take it back down to the lobby for reinforcement. He pressed floor one. Instead of going down, the elevator went up. It took the firefighter above the fire and continued up to the top floor. On the way up, the firefighter transmitted a Mayday signal. He forced open the elevator door, safely exiting the car on an upper floor where there was no smoke or heat. This car was disabled.

A short time later, another elevator that was used to take firefighters up to the fire failed. The elevator with firefighters suddenly stopped and became stuck between floors. The company in the elevator transmitted a Mayday and notified the command post that they were stuck in the elevator, below the fire. They were not in danger and remained there until available firefighters on the scene could extricate them from the elevator (fig. 13–4).

Fig. 13–4. An eight-year study of 179 major high-rise buildings in New York City revealed 59 elevator failures.

The second elevator was disabled. After the fire was extinguished, a visit to the fire floor revealed that another empty elevator had been summoned to the fire floor and had the door opened, the car interior burned to a crisp. In all, three elevators failed at this fire.

A three-year study on 9/11 by the National Institute of Standards and Technology, released on June 23, 2005, recommended that elevators in high-rise buildings be built with more robust shaft walls and with electrical systems that will not fail if exposed to water from hose streams or sprinklers. Unfortunately, these code changes will not be retroactive. Improved fire-protected elevators will only apply to new buildings and not to existing high-rise residential buildings. Beware of an elevator during a fire.

Plasterboard Walls

The walls separating apartments, hallways, and stairways in high-rise residential buildings are plasterboard; they are no longer made of masonry. During a serious fire in a high-rise, the plasterboard partitions separating the apartments from the hallway can fail owing to the fire's heat and the firefighters' hose streams. After a serious fire, sometimes only the steel studs separating the apartment from the public hallways remain; large sections of the plasterboard walls will be missing. This never happened when the apartment walls were constructed of masonry.

Construction of low- and middle-income high-rise residences in U.S. cities during the past 30 years was financed and controlled by a federal agency. This agency did not have to comply with many local city or county building codes. These high-rise residential buildings were constructed and designed under regulations of building codes that were performance codes. A performance code allows the use of any material that performs well in a 75-year-old furnace test fire. Nothing is specified.

By contrast, older high-rise residence buildings were constructed under what was called a specification code. This code specified that walls separating apartments were to be masonry. The code sometimes even specified the size and type of masonry to be used to build the wall. Apartment walls built under the specification code were masonry and were hard to penetrate. How they were to be constructed was exactly spelled out. They were required to be of mortar and brick masonry construction.

In the 1960s, the construction industry and builders successfully lobbied to have the U.S. specification codes changed to performance codes. Apartment walls in high-rise residential buildings, under the performance codes, are allowed to be built of any material, as long as they perform well in a furnace test fire and last for the required hourly fire-resistive rating. An apartment wall in a high-rise residential building since the 1960s is usually constructed of two sheets of half-inch plasterboard. A fire wall of plasterboard is less expensive and can be constructed faster than a mortar and brick fire wall. Unfortunately, plasterboard fire walls when poorly constructed have large cracks and spaces at the top and bottom. These spaces through which fire may spread can be concealed by plasterboard tape. Also, workers running pipe or wire during renovation easily puncture these plasterboard fire walls. Children and adults can punch or kick holes through plasterboard fire walls easier than through brick and masonry walls, and during a fire, hose streams can demolish these flimsy fire walls (fig. 13–5). This means that fire walls in modern high-rise residential buildings are less effective than masonry fire walls for resisting fire spread. Furthermore, because of combination of the increase in size (height and area) of high-rise fire residential buildings, the increase in the number of people housed in high-rise residential buildings who do not know how to react during a fire, the hotter fires fueled by synthetic furnishing, large windows that allow wind to blow through apartments, and disabled self-closing apartment door devices, the transmission of major alarms to combat fires in high-rise residential buildings has become common.

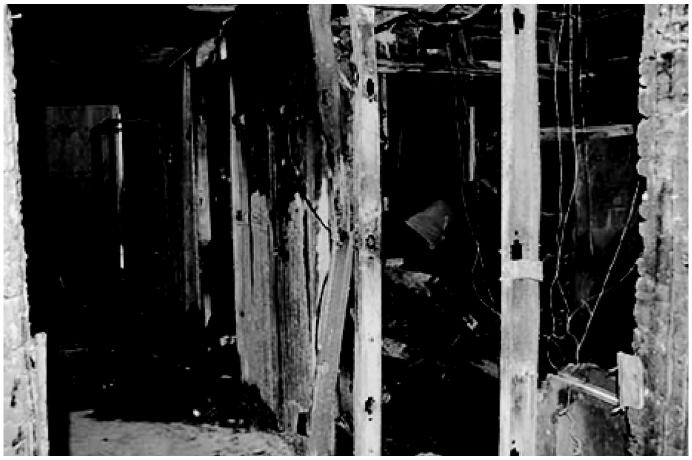


Fig. 13–5. During a fire, plasterboard walls fail when struck with a hose stream.

In the 1950s and ’60s, a fire in a high-rise housing project rarely required a greater alarm assignment because they were constructed entirely of masonry. These first-generation high-rise residential buildings were a credit to the term passive fire protection. These truly fire-resistive buildings could stop the spread of fire with their masonry walls, floors, ceilings, and stair enclosures.

Today, the term passive fire resistance is considered a joke in the fire service. Buildings do not stop fire spread anymore. There is very little passive fire protection created by construction. Firefighters using hose streams—that is, active fire protection—and sprinklers are required in order to stop fire in high-rise residential buildings. Modern high-rise residences should be called semicombustible construction, rather than fire proof or fire resistive. Fire and smoke can spread throughout the hallways, stairways, rubbish chutes, and poke-through holes.

Wiring in Public Hallways

The United States is becoming wired. The hallways of high-rise residential buildings now contain wiring for all types of communications—especially, cable television and computer Internet. Wire is being strung along the corners of hallways in high-rise residential buildings. Hallways with wires in corner conduits and wires in concealed spaces above a dropped ceiling are entrapment dangers (fig. 13–6). If these wires burn and fall, firefighters can be entangled and trapped in a burning hallway.

Hallways are part of an exit. Hallways should not be used as a conduit for wiring and piping. These wires may be covered by metal and synthetic conduits and

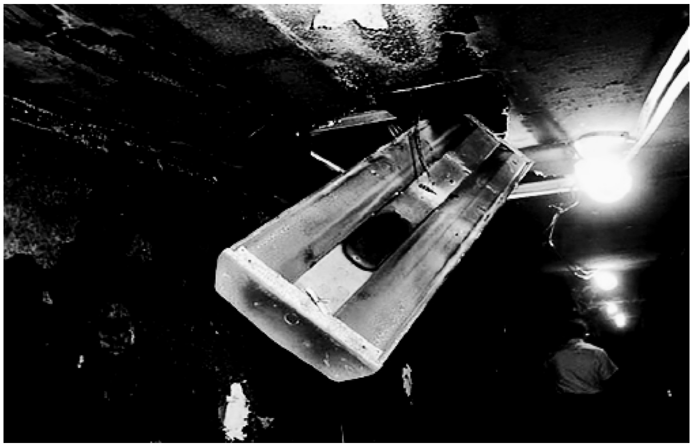


Fig. 13–6. Wiring for hallway lighting.

tucked into the corner of the ceiling and look harmless. However, during a fire, heat spreading from an apartment to the hallway by an open apartment door can destroy the covering, and the wires can fall. Wiring can drop like a net on top of firefighters advancing a hose line. This wiring can also entangle an occupant trying to escape a fire.

Firefighting Strategy

The strategy for fighting fire in a high-rise residence is defend in place. This means that everyone stays in their apartments while the firefighters extinguish the fire. The incident commander should not order an evacuation of a high-rise residential building during a fire. It is safer for everyone to remain in the apartment than to enter a smoke-filled hallway or stairway. For a high-rise residence, a total defend-in-place strategy is in order. Everyone stays put.

What confuses some is the firefighting strategy for a high-rise office building. The strategy for a high-rise office building is different. The strategy in an office building is to remove people close to the fire and tell others at distant floors and on floors below the fire to stay put. The reason for this strategy difference is that an office building's construction is different than that of a residence building.

An office building has an open floor. In an office fire, 50–100 people may be exposed to a spreading fire. By contrast, residential buildings have people in apartments separated by one- and two-hour-rated plasterboard walls. Also, an office building has several floors of walls, floors, partitions, and ceilings penetrated by ducts of a central air system through which smoke and fire spreads. Residence buildings should only have window- or wall-unit air-conditioners. There should be no ducts to spread smoke and fire in a residential building from apartment to apartment.

The problem is that most occupants of a high-rise residence do not know they are supposed to stay in their apartments, so they start to leave before the firefighters arrive. When the fire chief arrives, there are crowds of people in the stairways, and the chief cannot order for everyone to go back to their apartments. This is the reason why more and more occupants of high-rise residential buildings die in smoke-filled hallways and stairways.

The strategy when people have already started leaving their apartments is to assist the evacuation and to fight the fire at the same time. Most fire departments do not have the resources to carry out this double duty. There has to be more education given to people in high-rise residential buildings about how to react during a fire. There also has to be a communications system in high-rise residential buildings, to give occupants instructions during a fire. In addition, there should be a qualified fire safety manager on the premises 24 hours a day, seven days a week. This fire safety manager should be responsible for notifying the fire department when there is a fire in the building and ensuring that there is no premature evacuation before the firefighters arrive on the scene. The building management must also ensure that doors to apartments have self-closing devices in operating order.

Stair and Door Marking

Every door and stairway in a high-rise office building is marked with a number or a letter (fig. 13–7). Stair enclosures are marked with designating letters, and each floor is marked with the floor number. If a door that you are about to use to escape a fire is marked B12, it means you are entering stair enclosure B on floor 12. As you descend the stairway, on the inside of every door there should also be a marking—B11, B10, B9, and so forth—as you descend.

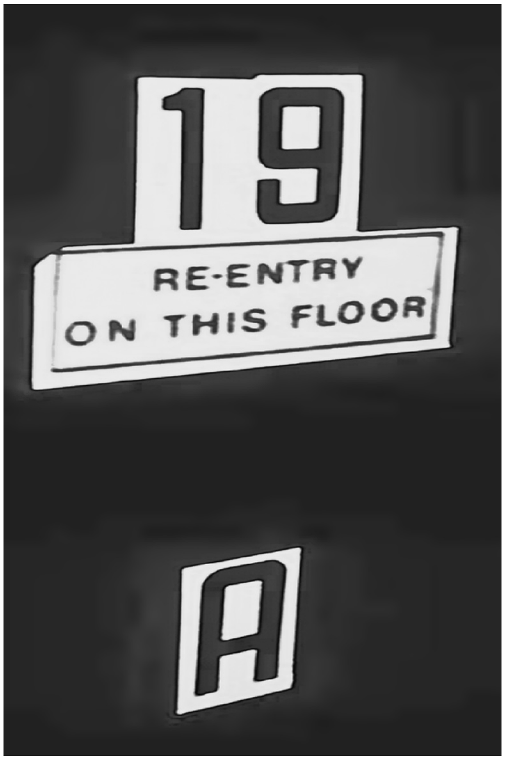


Fig. 13–7. Each stair door must be labeled with the floor number and the stair enclosure letter.

Most high-rise residential buildings do not have every stair enclosure marked with a letter and floor number on the inside and outside of every stair door. This marking may not seem important; however, it is right up there with sprinklers and smoke detectors as far as life safety in high-rise residential buildings is concerned. People trapped in stairs must be able to tell the firefighters exactly where they are located in order to be rescued. If the inside of the stair door does not have the enclosure letter and floor number indicated, firefighters will have to search every stair enclosure and floor systematically before the victim is found.

Stair and door marking is also important for firefighting strategy. Firefighters must be able to identify the floor and the stairway in which they are operating hose lines and searching. Without stair and door marking, it is impossible to conduct an effective high-rise firefighting strategy.

Public Hallways

A public hallway is a corridor that connects the stairs to the apartments. The public hall becomes involved in fire when a burning apartment door is left open by an occupant who flees a fire. The public hallways in some modern buildings are windowless spaces. When a hallway fills up with smoke and heat, it traps people in their apartments. A smoke-filled hallway does not allow any other occupant on the floor to leave. This is one reason for the total defend-in-place strategy. It is safer for occupants to remain in their apartments during a fire. If they attempt to leave and become trapped in a smoky hallway, they could become disoriented and/or trapped and could die.

The design and layout of hallways in high-rise residential buildings has also have an effect on firefighter safety. For example, a White Plains, New York, firefighter took an elevator to the fire floor and was killed in a hallway in a high-rise residence that filled with fire and smoke; two Memphis firefighters became disoriented and trapped in a hallway of a high-rise residence; and three FDNY firefighters were trapped in hallways in high-rise fire-resistive residence buildings.

Hallway Central Air Systems

At a fifth-alarm fire in a 34-story high-rise fire-resistive apartment building, I was receiving radio reports that the fire had spread to the floor above. Another report said that fire had already spread four floors above the fire. I thought, “This is supposed to be a fire-resistive building. How could this fire be spreading so rapidly?” What I discovered after the firefighters fought their way down the 40-foot burning hallway with two hose lines and finally extinguished the blaze in the apartment was that the occupant who fled this apartment fire had left a door with a disabled self-closing device open. Consequently, the fire spread to the hallway, and even though there were no windows in the hallway, there was a central air system with ducts providing fresh air to the hallways of eight floors; thus, fire was pumped throughout the hallways of eight floors by this central air system. When people on these floors opened their apartment doors, smoke poured into the apartments, and they quickly shut their doors. More important, though, firefighters could not enter the public hallways of these eight floors to search because of the smoke being spread by the central air ducts.

The incident commander should determine if the halls have a central air system. If so, order building personnel to shut down the hallway HVAC system to prevent the spread of smoke in the hallways.

Summary of Safe Firefighting

Take the elevator to two or more floors below the fire and walk up the stairs the rest of the way. After locating the fire apartment, note the location of the stair enclosure and its relation to the fire apartment, in case a retreat becomes necessary.

Connect a large-diameter hose line to the standpipe on the floor below the fire. Start a second hose line and have it connected to the standpipe outlet in the stair enclosure two floors below the fire. Bring another length of hose. If the fire has already spread into the hallways, this line may be required to back up the first line and to advance side by side down the smoke- and heat-filled hallway leading to the apartment fire.

Attempt to get access to an adjacent open apartment for a refuge before starting forcible entry. Size up the hallway layout. If it suddenly fills up with smoke, you could become disoriented and trapped.

Check to see whether the attack hose team is ready to advance the hose line on the fire.

Control the door during forcing and after it is forced open. Use a six-foot hook or rope with a slip knot on one end that is tied around the doorknob. This may prevent the door from suddenly flying inward from the impact of the forcible-entry tool. After entry through the apartment door has been forced, if fire is severe and the hose team is delayed, close the apartment door, to stop flames, smoke, and heat from coming out into the hallway. At a serious fire, wait for the hose line's arrival and search behind the safety of the advancing hose stream.

At a small fire where heat and smoke are not severe, one firefighter may be assigned to remain in the public hallway to control the door while a team searches inside. Firefighters inside the apartment may be called back to the door by this firefighter if fire conditions deteriorate. After all occupants and firefighters have been accounted for and evacuated, the door should be closed. This may prevent the hallway from filling up with smoke and heat.

Venting of a fire in a high-rise residential apartment building can usually be performed only by a firefighter on the floor above the fire by reaching down with a tool that breaks the windows of the fire apartment below. This firefighter, venting the window from above, must assess the wind blowing into the apartment window. If the window about to be vented is on the upwind side of the building and there is a strong wind blowing, the venting could cause wind to blow through the fire apartment and force the firefighters searching and advancing a hose line to back out of the apartment. If the apartment door is not closed, the smoke and heat can force firefighters to back out of the hallway into the stair enclosure. Wind blowing into the path of advancing firefighters stops most fire extinguishment efforts in high-rise residential buildings.

Wind blowing through a window broken by the fire's heat or through a sliding glass door to a balcony left open by a fleeing occupant can turn a one-line fire into a major-alarm fire with fatalities. If there is a strong wind blowing, the strategy may be to have the hose team advance the hose line without venting. When the decision is made not to vent owing to wind, the fire officer must notify the incident commander of this decision. If wind prevents the advance of an attack hose team down a hallway and into an apartment, the following actions should be taken. The incident commander should order the firefighters back to safety and the door to the apartment or stairway closed. When all firefighters are in a safe position, the strategy is to use an outside master stream or a hose team advancing from a ground ladder through the apartment balcony or window. This fire-extinguishing advance will be from the upwind side of the burning apartment. The master stream may be used to stop autoexposure from to a window above, by directing the stream at the spandrel wall.

Public hallways in high-rise residence buildings can be 100 feet long. If the fire extends out of an apartment into the public hallway and the hall surface has many layers of paint buildup over the years or if a combustible wallpaper lines the walls and ceiling, there could be a flameover in the hall. Flameover is when flame spreads along the combustible surface of the walls and ceiling of a hallway. Firefighters advancing a hose line down a hallway may be encircled by flames spreading over their heads and around them.

Hallways in high rise apartments are often L-shaped or T-shaped passageways, and large portions of these hallways can be dead-end areas where occupants and firefighters can be trapped. A dead-end hallway is an extension of a hallway beyond the exit. This forms a pocket in which an occupant or firefighter disoriented by smoke can become trapped. Since there is only one exit, flame and heat coming from a burning apartment's doorway may prevent escape. This can occur when the flaming door is situated between the exit and the dead-end portion of the hallway where the occupant or firefighter is trapped. When inspecting buildings, fire officers should train firefighters to note dead-end portions of hallways.

Running electric wires for cable television and air-conditioning above a panel ceiling in the hallway of a high-rise residential building can create a ceiling void in which fire may spread over the heads of firefighters. In some instances, poke-through holes from an apartment to a ceiling void for air movement or electric wire can allow fire spread from an apartment to the hallway. Before the apartment door is opened, if there is a panel ceiling in the hall, push up a ceiling tile to check for fire in the ceiling space. If spreading fire in the void space above weakens the ceiling supports, the lightweight metal frame and electric wire may collapse down like a steel net over the heads of firefighters in the public hallway. You have a hallway fire in addition to an apartment fire. Do not enter the apartment, and close the apartment door. You must extinguish the hallway fire before attacking the burning apartment.

If the standpipe outlet is in the public hallway instead of inside the stair enclosure, do not connect the hose. It is too dangerous to connect a hose line to a standpipe in the public hallway on the same floor as the fire apartment. Smoke and heat could fill up this area when the apartment door is opened. The hose might have to be abandoned. When a high-rise residential building has the standpipe riser outlets in the public hallway, firefighters should still connect the hose to the standpipe on the floor below the fire and stretch the hose line up the stairway to the fire floor. To do this, the self-closing doors to the stairway on the floor below and the on fire floor would have to be opened to allow the hose line through; therefore, smoke and heat would still enter the stair enclosure. Locating the hose outlet in the public hallway is poor fire protection design.

At a high-rise fire, stairways have to be designated as either attack or evacuation. The firefighters use the attack stairway. This stair will fill up with smoke. People in the building should be directed to stay in their apartments. The firefighting strategy is total defend in place (fig. 13–8). Firefighters can search the floors above by using the designated evacuation stairway. High-rise residential buildings should have public-address systems accessible from the lobby to instruct residents to stay in their apartments.

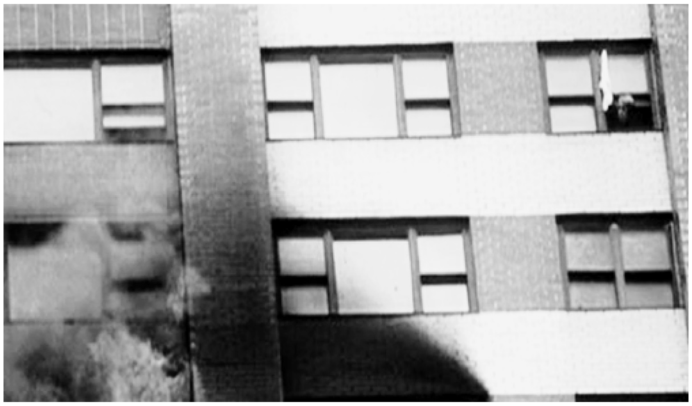


Fig. 13–8. The woman at the window is safe as long as she stays in her apartment.

In the United States today, high-rise residential buildings pose a more dangerous fire problem than high-rise office buildings. Firefighting in high-rise residential buildings is more dangerous than firefighting in an office building; similarly, living in such a building is dangerous. Each year, increasingly more occupants and firefighters die in fires in high-rise residential buildings than in fires in high-rise office buildings.

In a study by the National Fire Protection Association, during a 10-year period, 90 people died in fires in high-rise residential buildings; during the same period, only 10 people died in fires in high-rise office buildings. Despite these findings, when we compare the two different high-rise occupancies, we find that building codes for high-rise office buildings have much more and effective built-in fire protection. Specifically, a high-rise office building is required to have automatic sprinklers, a smoke-activated fire alarm system, 24-hour supervision, a public-address system to give instructions to occupants, and stairways and doors designated with identifying letters and floor numbers so that if necessary occupants can be directed into evacuation stairs. Not so with high-rise residential buildings, which are not required to have any of these lifesaving features.

The high-rise residential building of the past depended solely on fire-resistive construction to safeguard occupants. Today, however, high-rise construction is no longer fire resistive. The construction alone cannot be counted on to stop fire and smoke spread. Smoke and fire can spread throughout several floors by way of poke-through holes and compactor chutes. Lightweight, plasterboard-construction partition walls collapse under the impact of firefighters' hose streams. HVAC systems have ducts that penetrate floors, allowing smoke to spread throughout public hallways. Flames spread from window to window. The modern high-rise residential building of today is less fire-resistive and less safe than the older, fire-resistive high-rise residential buildings.

14

HEAVY TIMBER FACTORY FIRES

After 42 years of inspecting and firefighting in all type of buildings, I have never seen a true heavy timber (type IV construction) factory building. I have seen a lot of good imitations, but never the real thing. To be a true heavy timber-constructed building, the structure should have masonry walls and interior structural framing wood columns with dimensions of at least eight inches by 8 in.; this I've seen. A heavy timber building must also have girders at least six inches thick; I've seen this too. Finally, a heavy timber building must have 4-in. thick floors (i.e., tongue-and-groove planks, not less than 3 in. in thickness and covered with 1-in. flooring laid sideways). This last requirement has escaped me. I have never seen a factory or mill building with this floor. In fact, the floors of the heavy timber buildings I have observed looked pretty bad. Nevertheless, as the saying goes, if it walks like a duck and quacks like a duck, it is a duck.

Heavy timber buildings had their origin in New England. They provided structures for the birth of the U.S. textile industry. They were identified as *mill* or *plank-on-timber* construction and were built as factories during the Industrial Revolution of the last half of the 19th century. In addition to factory occupancies, this construction is today used for storage buildings, churches, office buildings, bowling alleys, waterfront piers, and military hangars (fig. 14–1).

During the 1800s, heavy timber textile mill factory buildings were constructed four to six stories high. These heavy timber factory buildings were considered the first

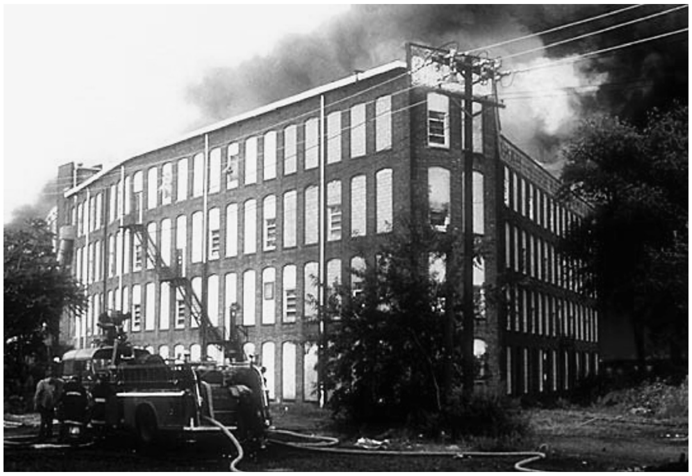


Fig. 14–1. Heavy timber (mill) construction.

high-rise buildings in the country. Just like the high-rise buildings of today, those heavy timber buildings imposed two important strategic conditions on the local fire chief: First, some floors were beyond the reach of ladders. Thus, outside rescue and outside hose attack were not options. Second, rescues and firefighting on the upper floors were limited to interior actions of the firefighters. There could be no window ladder rescues of people trapped on the upper floors. Victims had to be reached from inside by firefighters battling smoke and flames. If the firefighters could not crawl through the dense smoke and fire to reach them, victims trapped at burning windows had to choose between jumping and burning to death.

Like today's high-rise office buildings, heavy timber factory buildings had large, open floor spaces of up to 30,000 square feet. If engulfed in fire, this large interior space is beyond the extinguishing capability of firefighters' hose streams. Automatic sprinklers are necessary to protect such large-area occupancies and people working inside.

Life Safety

Many people work in heavy timber factory buildings used as textile mills. Hundreds of women and men working machines in a factory will have to be evacuated during the initial stages of a fire. Firefighters should assist in this evacuation and fight the fire, if present in sufficient numbers at the scene. If, however, there are too few first responders on the scene, the evacuation of workers should take precedence over firefighting. In firefighting, life safety is the number-one priority, and fire containment and property protection are the second and third priorities, respectively.

Evacuating large numbers of employees from a textile mill will be more orderly than the evacuation of people from public assembly and residence occupancies. This is because workers in textile mills are trained in procedures of evacuation. Fire drills are conducted each year, and some employees are given roles to organize, coordinate, and control a total evacuation of the building during a fire. Employees are assigned fire safety duties in addition to their normal factory duties. These duties are listed on a fire organization chart. Workers are assigned as follows:

- ***Fire wardens.*** Employees trained to coordinate the evacuation of workers on each floor
- ***Fire brigades.*** A trained group of employees ready to respond to and extinguish small fires
- ***Searchers.*** Men and women who check dressing rooms and restrooms to ensure that those areas do not contain workers unaware of the emergency evacuation
- ***Fire alarm box runners.*** Workers who transmit a fire call to the fire department
- ***Door holders.*** Employees who assist people leaving a floor by holding the door open and, most important, closing the door when all people are out

Firefighters should encourage the efforts of these employee fire evacuation personnel whenever possible. Fire evacuation employee organizations and evacuation fire drills in heavy timber factory buildings in New York City were first required by the New York State labor law enacted after 146 women died in the Triangle Shirtwaist fire in 1911. Such organization of employees for evacuation and control in case of fire is still required, and fire drills are held routinely. The law is now the legal basis for the requirement that fire safety organizations be established in high-rise office buildings.

Sprinklers and Standpipes

The construction of heavy timber factories and textile mills in the 1860s and ’70s brought about the invention of all types of automatic fire protection. Automatic sprinklers allowed the structures to grow in height and area throughout the United States. Sprinklers saved lives and extinguished fires even when local fire companies did not have the resources to quench a fire. Small fires were extinguished by sprinklers, and then company employees were organized into a fire brigade that would mop up the smoldering content. Sprinklers allowed large numbers of people to work safely in factories and textile mills during the Industrial Revolution. Over the years, additional fire protection measures, such as fire alarms and hose standpipe systems were designed to provide fire protection to these castles of commerce.

Today, when firefighters respond to a fire in a heavy timber building, the first hose lines should supply the standpipe and sprinkler systems. Many old heavy timber mill buildings are vacant or in disrepair, and the fire protection standpipe and sprinkler systems have been shut down and are out of service. In such cases, when the fire has gained considerable headway, defensive firefighting tactics are employed simply to protect exposures, allowing the structure to burn. If, however, the fire protection systems are in service, the standpipe system gets the first supply line. This is to protect the firefighters searching and entering with hose to use with the standpipe. The second supply line goes to the sprinkler system. The third and fourth supply lines should double up the first two lines supplying the standpipe and sprinkler systems’ siamese inlets.

A pump operator must understand that the first line goes to the standpipe to protect firefighters, but the supply to the sprinkler may be more effective in the initial fire extinguishment effort. When the sprinkler head or heads have initially fused, the system delivers water from the storage tank supplied by the factory roof tank. The water tank has a limited supply, so if the fire continues to spread, the sprinklers must be augmented by fire department pumpers. The sprinkler heads will have already opened and will be operating, discharging water on the fire before firefighters arrive on the fire floor. The pumper, fed by a hydrant, can provide a continuous supply to the sprinklers. In most instances, sprinklers control a fire even before firefighters arrive.

Sometimes, water problems occur during a fire owing to insufficient supply or low pressure when both the sprinkler system and firefighters’ hose streams are operating. The water supply demands of a burning heavy timber building are great, and a chief sometimes must choose between the sprinkler system and the standpipe supply to hose streams. If the hose streams cannot extinguish the fire and supply is continued to the standpipe and the sprinkler supply line is shut down owing to limited water availability, the fire department can be held liable by the building owner and the insurance company. For example, if sprinkler discharge causes smoke to stratify on a floor and a sprinkler supply is shut down to allow smoke to lift and let firefighters locate the fire and the fire spread, the actions of the chief could be challenged in court. If the incident commander has to choose between using the sprinkler or the standpipe system because of limited water supply, the sprinkler should be supplied with water, and firefighters should be withdrawn to safety.

First Attack Hose Line

Large-diameter lines should be stretched from hydrants to pumpers or hose manifolds positioned near a burning heavy timber building. The first line stretched inside the building to attack a fire in a heavy timber building should be the largest hose available. If 2½-inch hose is on the apparatus, it should be used as the attack hose, even if it takes more time; in other words, stretch the big stuff. A large hose will be needed to produce a large amount of water to quench a large fire in an open factory floor of the heavy timber building (fig. 14–2). Also, the hose stream must be able to reach from the stairway to the far corners of the open factory floor. Firefighters probably will not be able to make a close approach in a large open floor owing to the large flame front on arrival.

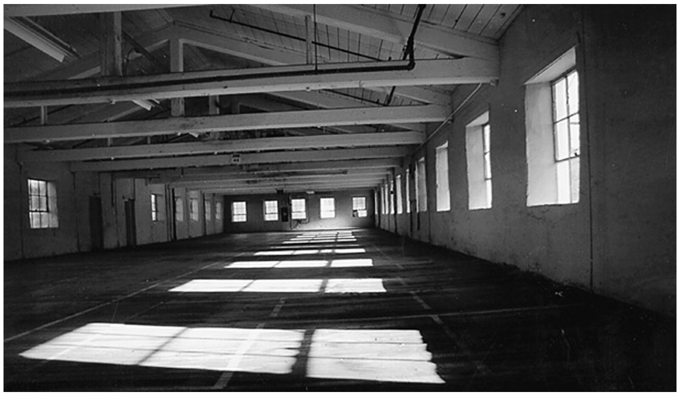


Fig. 14–2. A large open floor area in a heavy timber building.

There will be no partition walls to shield firefighters advancing for a close-up nozzle stream attack, so the line may have to be operated from the stair enclosure before the hose team can advance. Firefighters should take the attack hose, in rolled-up or folded lengths, up to the floor below the fire, where they will connect the hose to the outlet. Firefighters should then stretch up the stairs to the fire floor, open the door, and attack the fire. Four lengths of hose should be with the first attack team. A large open factory floor can be 200 feet deep and 100 feet wide. One 50-foot length is required for the stairway up to the fire, and 150 feet of hose is needed for advancing on the fire floor.

One advantage to heavy timber construction is the absence of concealed spaces that allow hidden fire spread. The interiors of these buildings are not finished, so the interior walls could be exposed brick and the ceiling an exposed open joist under the floor. Heavy timber columns and girders usually are bare wood. If firefighters can see the fire, they can hit it with hose streams. Ninety-five percent of fires in the United States are extinguished by the first attack line. Therefore, if firefighters can drag the nozzle of the first attack hose to the seat of the fire, they have a chance to extinguish the fire and save the building. Knowing this fuels the optimism of all firefighters entering a burning building.

Second Attack Hose Line

The second hose line automatically backs up the first line. Exposures are not a problem during the initial stage of a fire that is confined to one floor in a heavy timber factory. Fire spread to nearby exposures will become a major problem if the fire is not extinguished. During the initial attack, all the water power available is required at the fire floor.

Heavy timber factory buildings, high-rise office buildings, churches, bowling alleys, piers, and supermarkets all require firefighters with two large-diameter attack lines to extinguish a fire. This is because the large open space can allow a large body of fire to develop, possibly beyond the control of one attack hose line. Two attack lines will be needed to put out the fire in the open space. One line will be required to extinguish the fire, and the second line will protect the firefighters advancing the attack hose. Even if the fire is not large, these buildings often contain sewing machines and large tables where fabrics are laid out and cut. Beneath these tables, fabric or flammable materials are stored, and fire smoldering beneath the tables may not be fully quenched by the first attack hose stream or the sprinkler discharge. While the first line advances and extinguishes the fire near the ceiling level, the second line puts out small fires in these sheltered areas.

Third Attack Hose Line

In a heavy timber–constructed factory, warehouse, or textile mill, there will be large vertical openings between floors, such as open elevator shafts, conveyor belts, or shaft or glass openings to allow in light from an upper-floor skylight. More important, these vertical openings are positioned one on top of another, such that flames spreading vertically will travel to the upper floors quickly. Because of these shafts and floor openings, fire in a textile mill can spread much faster than hose lines can be positioned.

As soon as possible after the first and second lines are put in operation, the floors above must be checked for fire spread. Once the building is fully engulfed in spreading fire, it is unlikely that vertical fire can be stopped. Flames and smoke will quickly break out on the top floor and start to bank down. The surface area of interior combustible wood floors, ceilings, timber columns, girders, and floor beams will add dramatically to the fire spread. The general rule of thumb is that the fire on the fire floor and on the floor above must be extinguished; otherwise, all firefighters should be withdrawn from the building, and an outside defensive attack should be quickly ordered.

Ventilation

The heavy timber mill or factory is usually an isolated structure. An aerial ladder will be needed to gain access to the roof for venting. The first responders must vent at roof level to reduce the smoke and heat flowing up the stairs and open shafts and to prevent fire from accumulating on the top floor and then banking down on lower floors to trap firefighters. Going to a roof of a burning heavy timber building is dangerous, owing to rapid vertical fire spread from floor to floor, which can lead to entrapment on the roof. By the time a firefighter climbs an aerial to the roof and vents the roof openings (stair bulkheads, skylights, and tops of shafts that terminate on the roof), flames and radiated heat issuing from the windows near the ladder could prevent him or her from going back down.

If roof venting is attempted but the ladder is not required for rescue, it should be positioned on the upwind side of the building away from the fire. The roof vent firefighter should have a portable radio, and another firefighter should be stationed on the turntable with a portable radio to warn the firefighter working on the roof of the danger of an approaching flame front from windows near the ladder. The firefighter on the roof should quickly remove skylights over all stairs, chop open the bulkhead doors, and force open all scuttle covers and the skylight over the elevator and vertical shafts. As soon as venting is complete and the incident commander is notified that the mission has been accomplished, the firefighter should leave the roof.

Venting top-floor windows from the roof and conducting a search of the upper floors via a fire escape or leaning over the roof parapet is not an option when fire is spreading rapidly in a heavy timber building. Flame spreads too quickly throughout the open floors because there are few partition walls to restrict extension. Roof venting of stairways and shafts is the primary venting mission at a fire in a heavy timber building. Window venting should be conducted, to assist in the advancement of the attack hose lines. Portable ladders and aerial ladders may be positioned for window venting.

Interior Fire Spread

Fire spreads rapidly in the interior of a heavy timber building because of an unusual construction feature not found in other types of buildings—a large amount of exposed wood surface area and the lack of partition walls to restrict fire spread. Interior fire spread on one floor can be rapid owing to the exposed wood surfaces in the heavy timber design: wood wainscoting on the walls, the wood surface of the columns, wood girders, and the wood underside of floor above. All of this exposed wood is not covered by plaster as in ordinary construction.

A heavy timber building is said to have a low surface-to-mass ratio. This means it is difficult to start a fire because of the large dimensions of its wood structural members, such as girders and columns. However, a heavy timber building has much exposed wood surface, and this causes tremendous heat and flames. The heat and flames radiate out of the windows and spread across large distances. It is not unusual at a seriously burning heavy timber building fire for exposed building 80–90 feet away from the main fire to be ignited from radiated heat waves (fig. 14–3). Another problem in a textile mill or factory building can be floors, which have been soaked with the oil and combustible liquids used in machines over decades. These oil-soaked floors will add to the fire and heat. Also, a 19th century heavy timber building will have many unprotected openings that allow vertical fire spread throughout, from the cellar to the roof.

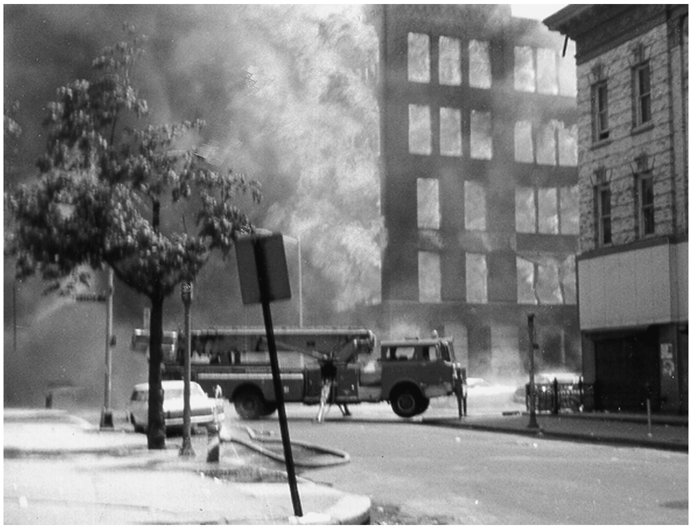


Fig. 14–3. Fire apparatus must be repositioned to prevent damage from radiated heat, rapid fire spread, and collapsing walls.

There may be open elevator shafts, open stairs, open conveyor belts, open package chutes that were used to move merchandise from upper to lower floors, and even a large skylight in the center floor opening. When searching for victims or fire spread inside a burning large-area heavy timber building, firefighters can limit interior fire spread by closing fire doors, wire-glass windows, and outside metal window shutters. Many heavy timber factory buildings have fire-rated doors, windows, shutters, and floor coverings serving as interconnections between building sections. Firefighters should not overlook the importance of closing fire-rated enclosures through which fire could spread. This action can sometimes be more effective in limiting fire spread than a hose stream.

Exterior Fire Spread

Windows

Large windows were necessary in heavy timber textile mills to let light in because of the initial absence of electric lighting, at the turn of the century. This is a major contributor to exterior fire spread. Compared to those in ordinary construction buildings, these large mill windows allow more rapid window-to-window fire spread. If interior firefighting efforts are not successful and all floors of the timber building are engulfed in fire, there will be transmission of fire to nearby buildings by radiated heat. This heat will be radiated through these large (window) openings after they are melted by the heat of the fire.

Radiation

Radiation is defined as the transfer of heat through space. Radiation fire spread often occurs at fires in buildings of heavy timber (mill) construction. However, when fire spread by radiated heat occurs, it is undetectable. Radiated heat spreads suddenly, in all directions, and it is invisible. The chief will not recognize that it has happened until the exposure starts smoking or ignites in flames.

Radiation fire spread does not occur often. An incident commander will experience radiation fire spread once or twice in a career.

Convection

Convection fire spread is a common type of fire spread. Fire chiefs will inevitably encounter convection fire spread. It can be seen as flames spread from window to window.

Autoexposure

Before the radiation heat problem becomes severe, convection currents of heat will spread fire from floor to floor during a fire in a heavy timber building. This window-to-window-above fire spread, called autoexposure, is defined as convection fire spread. Convection is the transfer of heat by fluids. A gas or liquid is a fluid. Flame is the gas that transfers the heat during a fire. As air is heated, it becomes lighter than the surrounding unheated air and rises.

Large burning embers

Flying brands (windblown pieces of burning wood embers) are another exterior fire spread problem encountered at heavy timber mill fires. During a nighttime fire in a heavy timber building, flying brands will light up the sky. During the daytime, they may be overlooked owing to the smoke issuing from the burning building. These airborne burning embers must be considered a serious fire spread problems.

When a windblown (convection currents) hot wooden ember lands on a roof and ignites wood shingles, the spread of fire to the roof can be considered heat transfer by conduction. The fire ground commander must consider fire spread to nearby buildings by burning embers landing on roofs, porches, and decks. Even if there are no surrounding buildings, the fire spread to wooded areas, leading to wildfires, must be considered. Dispatchers should be directed to send units for brand patrol, to check out surrounding areas for spot fires. This must be part of the firefighting strategy at a serious fire in a heavy timber building.

Change of Strategy

New York City has heavy timber buildings throughout the five boroughs; however, the largest district of heavy timber construction is located in an area of Lower Manhattan. There is a district of former factory and storage buildings in a neighborhood called Hell's Hundred Acres by the FDNY. This name was given to the area of heavy timber buildings because many firefighters were killed by burning building collapses there in the first half of the 20th century.

The collapse danger posed by these heavy timber buildings is a multilevel failure of the structural framing, as well as floor and wall collapse. During an uncontrolled fire, first the cast-iron structural framing (columns and girders) fails; this triggers the floors to cave in, and then the falling floors cause the walls to collapse (fig. 14–4).

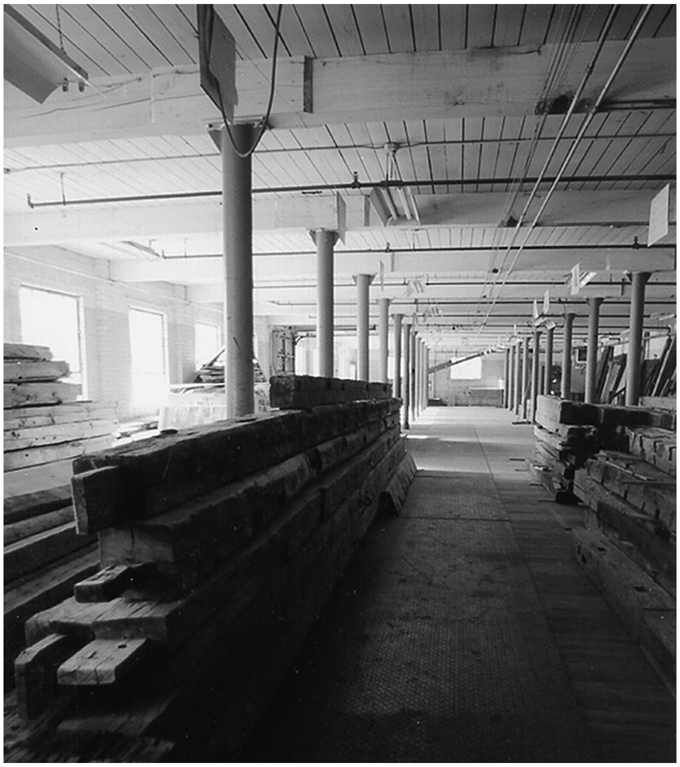


Fig. 14–4. Cast-iron columns support floors in a heavy timber building.

The area has become a trendy artists' colony, and the same century-old heavy timber buildings now exist as artist studios. The fire and collapse dangers still exist, and a defensive firefighting strategy established over the years still applies. As a result of deadly fires and building collapses, fire chiefs have realized how important it was to withdraw firefighters from these century-old heavy timber buildings if fires were not extinguished quickly.

The rule for firefighter withdrawal that has been passed down from veteran chiefs to new chiefs states that if fire is on two or more floors and the hose lines are not making headway, an outside attack strategy should be considered. Veteran fire chiefs knew they could not employ an inside firefighting strategy in a 100-year-old building that has large open floor areas, cast-iron columns, and large amounts of combustible content. To quote from the Board of Inquiry report on a 23rd Street fire in which 12 firefighters were killed by a floor collapse, the FDNY states,

> *It is our policy not to press interior attack once the fire extends beyond our immediate control or we are in doubt about the effects that the fire may have had on structural supports. All officers are instructed not to rely solely on the normal criteria for imminent collapse, such as cracks in walls, sagging beams, or smoke issuing from mortar spaces, but rather to regard every building on fire as a potential hazard at all times.*

Size-up Considerations

To stay aware at a heavy timber building fire, you must continually size up the fire from the inside and the outside. At most fires, during the early stages, the inside size-up is the most accurate. The fire officer inside can see more than the incident commander who is outside, at the command post. However, things change rapidly at a heavy timber building fire. When flames spread throughout a 20,000- or 30,000-square-foot floor area, when fire spreads to two or more floors or up a vertical shaft, or when fire spreads to a window above, the size-up from outside is more accurate.

At this stage of a fire, the officers inside may erroneously think they have the extinguished the fire, when from the outside, it can be seen that the fire has spread to one or two floors above. The officers inside cannot see the fire on the floors above their position. They will not be aware that flames have spread above them. Rapid fire spread several floors above the initial attack hose team will change the size-up's effectiveness. The size-up inside the burning building is incomplete and incorrect. The size-up of the fire chief outside, at the command post, is now the most complete and correct.

In this situation, the incident commander may order that forces inside withdraw, and the firefighters inside may not understand why the chief is ordering them to back out. They may question the chief's order to withdraw, thinking they have the better size-up situation awareness. "Chief, we've almost got it!" they might respond to the order to back out.

Fire officers must realize the best vantage for size-up of a fire can change from inside the burning building to outside very quickly. The inside size-up is more accurate at 95% of fires. However, at the other 5%, when flames spread to two or more floors or involve one floor and the roof, the outside size-up becomes the best. To ensure fire ground safety, two size-ups of a fire must be conducted: an inside size-up and an outside size-up. To do this, there must be an operation officer inside, sizing up the interior fire, and an incident commander outside, sizing up the exterior fire from the command post.

Protecting Exposures

A fire in a heavy timber building will be extinguished by the first-arriving firefighters, or the firefighters will be withdrawn as the blaze becomes a major conflagration. A fire in a brick-enclosed wood structure will quickly become a conflagration, spreading fire by radiated heat and airborne burning embers to nearby buildings. Abandoned drums and tanks of industrial chemicals may explode. Moreover, the building may eventually collapse. If the initial attack fails, the primary strategy will be to evacuate any occupants and firefighters and protect nearby exposures.

The first exposures to protect will be the fire department's apparatus. Apparatus parked around the burning heavy timber building will have to be moved away from the growing fire. As soon as the decision is made that the fire cannot be extinguished and the firefighters must withdraw, an order should be given for all chauffeurs to return to the street and reposition apparatus. As the fire spreads, the radiation heat problem in the streets around the perimeter of the building will quickly become severe. It may even prevent chauffeurs from reentering the cabs of their apparatus to drive them away from the flaming building and the potential wall collapse. Burned-out fire trucks and apparatus crushed under tons of bricks are a common sight around a smoldering heavy timber building. Fire trucks should be repositioned while you are setting up defensive streams to protect exposures.

There is a story of an FDNY fire ground commander at a rapidly spreading heavy timber building fire who repositioned fire trucks. The chief ordered a change of strategy—from interior to defensive—at a rapidly spreading fire and told the firefighters to move fire apparatus away from the burning building. From the command post, the chief saw a brand-new pumper near the building where flames were coming out a window and blistering a side of the truck. After the chief shouted an order to move the rig, the chauffeur told the chief that he was hooked up to a hydrant and could not disconnect the hydrant connection because of the radiant heat coming from the building. In other words, it was too hot: the radiated heat from the building made the space between the pumper and the hydrant unbearable. The high-ranking chief also was responsible for purchasing and maintaining the entire fleet of apparatus for the fire department. The chief, seeing one of his new apparatus smoldering, shouted at the firefighter, "Get in the cab of that truck and drive it away from hydrant anyway." The driver jumped in the cab and gunned the motor, tore the hydrant connection apart, and saved the pumper. Later, the chief thanked the firefighter and had a blistered fire truck equipped with a new 4½-inch suction inlet. The spot where the pumper was removed from the street was covered with brick from a collapsing wall.

Exterior defensive tactics

Defensive strategy at a burning heavy timber building will involve firefighters operating large-caliber hose streams from flanking positions, directing water on buildings to break up radiation heat waves spreading fire. There can be so much radiated heat that aerial master streams may have to be positioned at the street intersections and streams directed long distances, alternating between the burning building and the exposed buildings. The street between buildings will be too hot to enter. When preventing fire spread from a fully involved heavy timber structure radiating heat to another structure across a 60-foot-wide street, aerial master streams must be positioned in a flanking position.

There are two ways to direct an aerial master hose stream between buildings when radiated heat is spreading from one to the other across a street: order the firefighters to direct the stream onto the fully burning building and try to stop the fire coming from the windows; or use the stream on the exposed building. In this instance, the hose stream wets down the roof and wall surface of the nearby threatened buildings. If the fire generating the radiated heat is small, the strategy is to direct large-diameter hose streams at the burning building, to easily push the fire back into the windows. You should continue directing the streams at the burning building radiating the heat and extinguish the blaze. However, at a burning heavy timber building, there will most likely be little or no effect on the fire and heat when you direct a master stream in a flaming window. When this is the situation, you should change strategy.

The new strategy should be to wet down the surface of the nearby exposed building and direct the stream at the spandrel section of the wall (the wall surface between windows) and the roof cornice. Let the water run down the surface of the exposed building. Use a fog stream if possible to avoid breaking windows. The firefighter directing the master stream should try not to break windows. In all situations, when a nearby building is threatened, order for hand lines to be stretched inside the exposed building from the rear yard, just in case fire has spread into the interior.

Interior defensive tactics

When radiated heat is igniting buildings across a street from a burning heavy timber building, hose lines and portable deluge nozzles will also have to be stretched into the exposed buildings across from the conflagration. Firefighters and equipment must come from the rear yards and back alleys of the exposed buildings. The radiated heat will make entering the street between the burning building and the exposure impossible. The front siding of the exposed buildings may be burning. Hose lines should be taken into the building from the rear yards. In this case, firefighters are using the exposed buildings as a shield from the radiated heat in the street front. This radiated heat will ignite wooden window frames and roof eaves of nearby ordinary construction buildings. The firefighters with hose lines stretched from the rear must prevent this surface fire from entering the building. When firefighters stretch hose into an exposed building across from a burning heavy timber building and prevent interior fire spread, the hose streams may be applied on the burning building across the street from the exposed building. The strategy will change from defensive to offensive.

When stretching a hose line into an exposed building from a backyard to protect the building from fire spread, there is a special way the hose should be stretched. Hose stretched into an exposure building must have sufficient number of lengths to be able to reach all points on every floor and the roof. Radiated heat may ignite wooden windowsills in a brick building; the wood eaves or cornices may also spontaneously ignite from heat radiation and fire entering the top-floor roof space; and flying brands and embers from the heavy timber building may be landing on the roof, igniting it. Firefighters inside an exposed building must continually check the entire building for fire extension, from the cellar to the roof. Radiated heat may ignite a lower-floor window frame, the roof cornice, and any combustible part of the facade in between.

When the hose is stretched, the nozzle stream must be able to reach the entire building. For example, to protect a four-story building in the path of a fire from an adjacent one-story building, stretch six lengths of uncharged hose with a sufficient number of lengths to cover the roof and the top floor. However, the nozzle and several lengths could be taken back down to the first or second floor facing the fire when there is a greater risk of fire entry here. The uncharged excess hose is played out up the stairs to the top floor. Once it has been confirmed that there is sufficient hose to reach the roof, the hose is taken down the stairway, nozzle first, to discover fire or a point of possible entry of radiated heat. If flames enter on any floor or the roof, the hose could be repositioned and extinguish minor spreading fires at any location. The entire building could be protected by one hose line.

Firefighters assigned to protect an exposure near a burning heavy timber building must continually monitor all floors and the roof of an exposed building in the path of flames. Windows facing the fire should have any outside shutters closed. All open windows facing the burning building should be closed, and curtains or combustible furnishings near the closed windows should be removed.

The greatest danger presented by a burning heavy timber factory building occurs in the early stages of the fire. That is when initial search and attack are taking place, and firefighters have a greater chance of being caught by the unusually rapid fire spread that is possible in a burning heavy timber building. Unusually rapid vertical fire spread up through large and numerous routes—elevators, light and air shafts, conveyor belts, and open multi-floor chutes for moving stock, and large open windows—can trap firefighters. Also, large open floor spaces and open and/or nonoperational automatic doors and windows allow rapid horizontal fire spread that can trap firefighters.

The collapse danger of a heavy timber factory building does not present as great a danger during the second (fully developed flaming) and third (decay) stages of a fire, because radiation heat generated from the fire is so great that firefighters do not get near the building when walls start collapsing. The deadliest fire in a heavy timber building in modern times occurred in New England, where such construction originated. In December 1999, in Worcester, Massachusetts, six firefighters died after becoming trapped by fire inside a heavy timber structure, the Worcester Cold Storage Warehouse. Contributing factors of the firefighter fatalities were a fire set by homeless people in a partially vacant building, delayed alarm notification to the Worcester Fire Department, rapid fire spread up an open elevator shaft, dense black smoke buildup due to burning cork and plastic insulation on the walls, and a maze of freezer compartments.

15 FIRES IN NONCOMBUSTIBLE BUILDINGS

On December 20, 1991, four Brackenridge, Pennsylvania, firefighters were killed by a floor collapse in a noncombustible (type II construction) building. The building, a 75-foot-by-65-foot two story with full basement built in the 1930s, was an unprotected steel-supported structure with masonry walls and floors. The structural fuel load was zero. The structure was built of steel and concrete—no wood. There was nothing combustible in the structure. So how did this building burn, collapse, and kill four firefighters?

As one firefighter said, "It's the content, stupid, not the building." He is correct. Another way of saying this is, "From a fire protection point of view, the occupancy of a building is more important than the structure." What is stored inside a building has a greater impact than what it is constructed with. It is not the structural fire load but the occupancy fire load that creates the fire.

This building originally was occupied as an automobile dealership that sold new cars. The automobiles were without gas in the tanks, and there were a couple of offices—not much to burn. However, the automobile dealership went out of business, and the occupancy changed. A furniture-refinishing company moved into this noncombustible structure built of steel and concrete. Now, in the basement, there was furniture storage up to the ceiling. There was a wood-refinishing workshop and a paint-spraying booth near the front of the cellar directly below the first-floor entrance. Flammable paints, lacquers, varnishes, and thinners were stored in the basement refinishing workshop.

The fire started in the workshop. On arrival, two attack hose lines were stretched into the basement from the rear of the building to attack the fire. Heavy smoke prevented the lines from advancing from the rear of the basement to the front where the refinishing workshop was burning. Because of the bogged-down advance of the two lines in the basement, a third hose line was ordered stretched into the first-floor front entrance to prevent vertical fire spread up a stairway, extending from the basement to the first floor, that was located in the middle of the floor. Once firefighters stretched the third hose line through the front entrance on the floor above the fire, it was positioned near the stairway to stop vertical fire extension.

Then, a large section of the first floor collapsed behind the firefighters. The floor collapse cut off the escape of the firefighters back to the front entrance. As the floor collapsed, it crushed large drums of flammable liquid in the basement, and this caused a large fireball to erupt, rocketing up to the first floor, trapping four firefighters of Hilltop Hose Company Number 3. Killed by the floor collapse and fire were First Lieutenant Rick Frantz, David Emanuelson, Firefighter Michael Cielicki Burns, and Firefighter Frank Veri, Jr.

This concrete and steel noncombustible structure contained no combustible material. The high hazard content of the wood furnishings and flammable liquids created a tremendous fire. A postfire analysis revealed the series of events that caused the collapse. Heat from the cellar fire buckled the front unprotected steel column. This caused a girder to twist and move, in turn causing the steel floor beams supporting the front portion of the masonry floor to collapse (fig. 15–1). The masonry floor crushed metal drums of flammable liquid. This created an explosion, sending a ball of fire up to the first floor and killing the firefighters operating the third hose line. The cause of the firefighter deaths was the floor collapse. An unprotected steel column failed and caused an unprotected steel girder to fail, leading to the collapse of the unprotected first floor steel beams over the burning cellar workshop.

Today, public, residential, and commercial building construction in the United States is changing. Most new buildings on Main Street are noncombustible steel and masonry structures. This type of construction is more economical. This change from ordinary (type III) construction to noncombustible (type II) construction is very significant to U.S. firefighters. The open web bar joist used for roofs and floors in noncombustible construction is replacing the solid wood roof beam normally used in ordinary construction on Main Street. This steel roof and floor construction change applies to strip malls and shopping malls where we encounter store fires. Lightweight steel bar joist supports, steel sheet roof decking, and a suspended lay-in ceiling are replacing wood joists, plywood roof decks, and tin or plaster ceilings. This change in the roofs of a noncombustible building has advantages and disadvantages. The main advantage is that there is less to burn in the roof structure. The main disadvantage is that steel web bar joist will collapse fast under fire conditions.

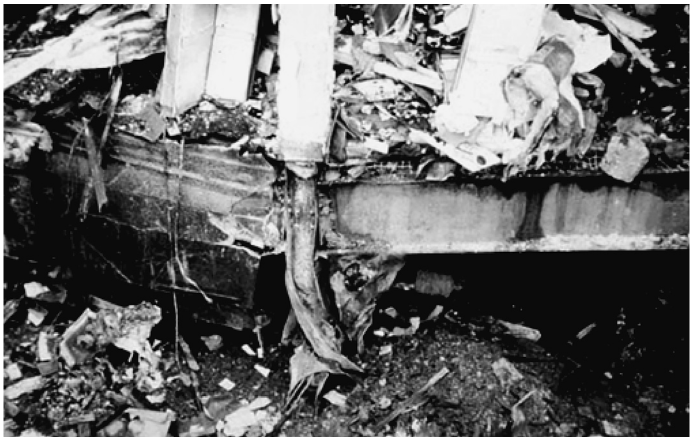


Fig. 15–1. The steel column twisted and pulled the girder back, which pulled the floor beams away from the front wall.

Noncombustible versus Fire Resistive

Noncombustible does not mean the same as fire resistive. If noncombustible steel columns, girders, and open bar joist are not covered with fire-retarding material, they cannot resist fire and can collapse quickly when heated by a fire. Steel is not fire resistive; it is noncombustible, and when heated by fire, it fails and can collapse a building. The steel does not burn when heated, but it expands, warps, twists, bends, buckles, loses its tensile and compressive strength, and does not support the building loads it was designed for. The lighter the steel, the faster it fails during a fire. It is well documented that noncombustible open web steel bar joists not covered with fire-retarding material can collapse within 5–10 minutes of fire exposure. Steel columns, girders, and beams in a fire-resistive building (type I construction) will be covered with fire-retarding material. Steel in a noncombustible building need not protected by fire-retarding material and can fail rapidly during a fire.

Noncombustible Construction

The materials used in a noncombustible building are steel, masonry, plasterboard, synthetic ceiling panels, and several layers of asphalt and plastic for a roof covering. The typical modern strip mall or shopping mall will have a structure of steel columns, steel girders, steel bar joist, steel wall studs, and a steel corrugated roof deck covered with a tar and plastic (fig. 15–2). Inside the stores, there will also be synthetic ceiling panels and plasterboard partitions. The only combustible material in a noncombustible building, besides the content, should be the asphalt and plastic insulation roof covering and the synthetic covering for electric wiring. Besides the burning content, smoke spread from the insulation in a type II burning building will be the primary combustion product. Again, the fire protection advantage of such a building is its noncombustibility.

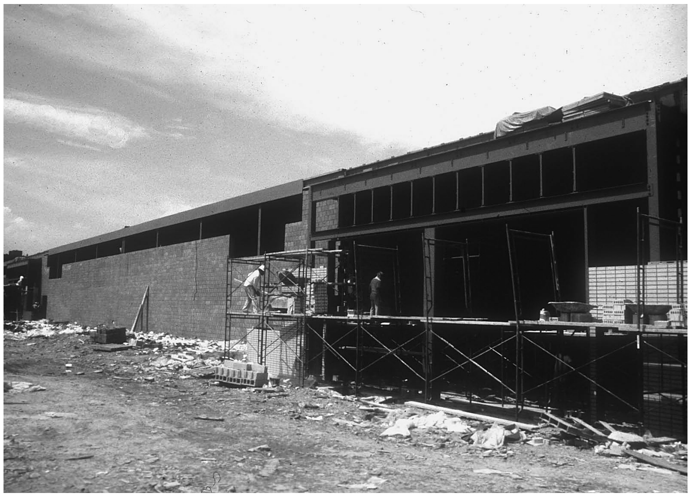


Fig. 15–2. A noncombustible building under construction.

Except for electric wire insulation and the roof deck, noncombustible construction does not add much fuel to the fire in the cockloft. The old ordinary construction strip malls and shopping malls had a large amount of combustible materials in the roof structure: wood beams, wood roof deck, wood bracing, and ceiling furring strips. Furthermore, there was the common roof space shared by adjoining stores. After burning through the ceiling, the large spreading fire in an ordinary-constructed store was often fueled by the lumberyard of the roof above the ceiling. This cannot occur in a noncombustible steel roof support system; the electric insulation and the asphalt and plastic insulation on the roof deck surface may burn and create a smoky fire, but there is no lumberyard of built-in fuel loading as in an ordinary-constructed strip mall. However, the noncombustible steel and concrete building presents a collapse danger.

	Fire spread potential	**Collapse potential**
small	Type I. Fire resistive	Type I. Fire resistive
	Type II. Noncombustible	Type IV. Heavy timber
	Type III. Ordinary	Type V. Wood timber
↓	Type IV. Heavy timber	Type III. Ordinary
great	Type V. Wood frame	Type II. Noncombustible

The main disadvantage of the new, type II construction to firefighters is the collapse danger. The fire protection engineers tell us a thin ½-inch unprotected steel bar joist truss roof and floor can collapse within 5–10 minutes of fire exposure. The firefighter's collapse size-up learned over many years of firefighting and used at burning strip malls cannot be used at a fire in a noncombustible strip mall. The roof and floor can collapse faster than anything we have experienced at other fires.

Firefighting Strategy

One-story buildings

The firefighting strategy for positioning hose lines during an offensive interior attack in a burning noncombustible one-story strip mall is as follows: The first line is stretched into the fire store and attacks the fire. Another hose line is stretched into the building and backs up the first line. The third line goes to the store downwind. The fourth hose line is stretched into the store upwind. The rear (exposure C) of a strip mall usually has a large truck-loading space and is not a severe exposure problem. If it becomes an exposure threat, then send a hose line there for protection. If the first and second lines extinguish the fire and the fire has conducted through the roof and ignites the roof covering, the third line is sent to the roof, and the roof-covering fire is extinguished (fig. 15–3).

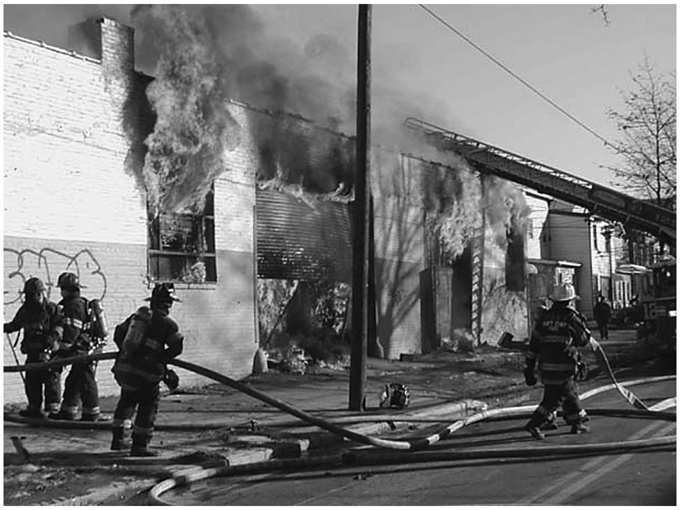


Fig. 15–3. After a fire is extinguished in a noncombustible building, check the roof covering for fire conducted through the steel roof decking.

Multistory buildings

If the type II noncombustible building is a multistory building, the firefighting strategy is to have the first line stretched to the fire floor. The second line is a backup line. The third line goes to the floor above. The backup line in both the strip mall and the multistory-building fire is used by firefighters to advance with the first hose line to the fire. The firefighters advancing the backup hose line direct water at the steel roof or floor support system if there is a danger of collapse. The water from the second hose stream cools the steel open web bar joists. This line is intended to prevent a roof or floor from collapsing on the firefighters advancing the first attack hose line. The second line can also prevent heat from conducting through the steel roof deck and igniting the asphalt/tar roof deck above.

The purpose of the second backup hose line sent into a burning store of a noncombustible building is the same as any backup hose line. The firefighters operating the second line protect the firefighter using the first line in case the line bursts or there is an explosion, flashover, or ceiling collapse or in case there is too much fire and two lines are needed for extinguishment. The backup hose line at a noncombustible building has an additional purpose. It is used to cool off the steel bar roof or floor joists when there is a danger of collapse. Any type of steel roof or floor joist can fail when the temperature of the steel reaches 1,000–1,100°F. This temperature is common in a structure fire. Directing the hose stream from the second line at the steel roof or floor joist may stop the expansion, warping, twisting, sagging, of steel when being heated by the content fire (fig. 15–4). The water from the hose line may even freeze a failing steel joist about to collapse. At a fire in a noncombustible one-story row of stores, the justification of the strategy of sending a second hose line with the first hose line and not in the downwind exposure is that there is less combustible material in the roof structure. The fire will not spread as fast in the cockloft of a noncombustible building as it does in an ordinary-constructed building. When sufficient firefighters arrive, the third line is sent to the downwind store to protect this exposed store. The interior fire spread problem in a noncombustible store is the conduction of heat through the underside of the roof deck. Heat conducted through the metal roof may ignite the asphalt roof covering above.

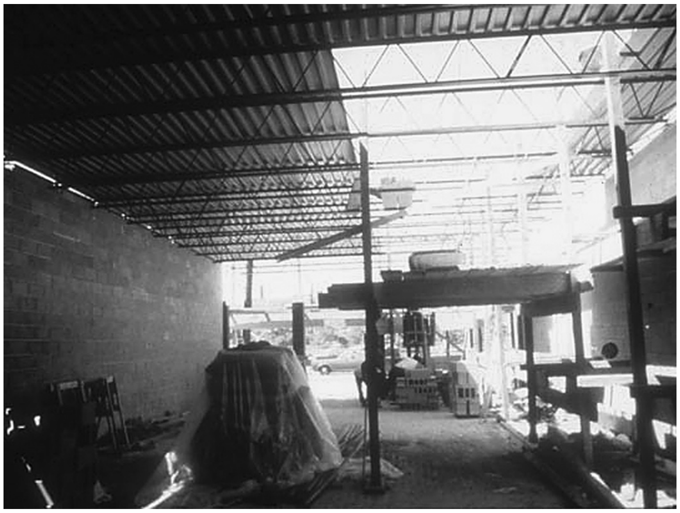


Fig. 15–4. The second hose line is directed at the steel roof supports.

A ground ladder should be placed on the upwind side of the building, and a firefighter should be sent to the roof to examine the asphalt roof covering for fire spread. If fire is discovered spreading across the roof covering, a hose line should be sent to the roof on the upwind side of the building. An aerial master stream should be positioned for possible use on the downwind side of the burning roof. A fast-moving asphalt roof-covering fire can be stopped by the aerial stream.

Firefighters should be positioned on the roof upwind of a roof-covering fire. The smoke and gases from an asphalt roof deck fire are flammable and can suddenly

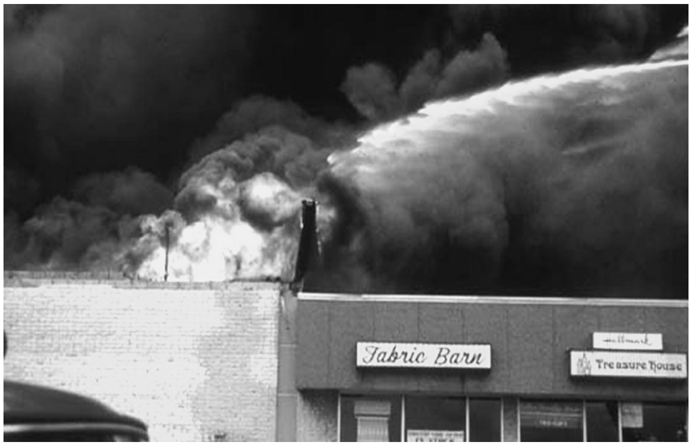


Fig. 15–5. In a noncombustible building, fire will spread along the top of the combustible roof deck.

flashover, burning firefighters working in the smoke and gases spreading ahead of the flaming roof. If the aerial master stream is used, firefighters on the roof must be notified and moved to a position of safety. A powerful master stream can knock a firefighter off a roof.

After a fire in a noncombustible building is extinguished, the ceilings are pulled, the common roof space is checked for fire spread, and the incident commander is notified of the conditions found. There may be fire spread of the content of the strip mall, there may be surface fire spread of the asphalt roof, and the combustible insulation in the roof space may smolder and generate large quantities of smoke. Nevertheless, there will not be the same rapid fire spread in the concealed roof space of a noncombustible construction as in ordinary-constructed strip malls. The main fire spread problem will be on top of the roof, not below the roof (fig. 15–5).

Roof Venting

Many progressive fire departments prohibit firefighters from operating on a roof known to have any type of truss supports. Some fire departments conduct only primary roof ventilation of the noncombustible building. Skylight and scuttle covers are vented, and then firefighters leave the roof.

Because the roof construction and the roof support system is steel in noncombustible construction, the standard roof cutting performed on ordinary construction, where the roof support system is wood, is not necessary. There will not be fire spread fueled by the roof support system in a type II building. Smoke ventilation is the major objective. Smoke venting can be conducted by opening roof skylights, scuttles covers, doors, and windows. After the skylights and scuttle covers are vented, the rear of the store is vented to assist the advance of the hose line from the front of the store. Doors and windows at the rear of the store are opened. When the initial attack hose team starts to advance, the front windows and doors are vented. Once the rear and front have been vented, cross-ventilation will be effective. Positive-pressure ventilation can improve smoke removal through the windows and doors of a one-story noncombustible strip mall store. There is less chance of drawing in fire by the use of positive ventilation in a noncombustible building because there is no wood framing in the roof and wall concealed spaces.

The key to safe operations at a noncombustible building is early identification of the steel open web bar joist. When a firefighter discovers a steel bar joist, he or she should immediately notify the incident commander. The incident commander can take precautionary actions once notified of the steel truss construction. If large amounts of sparks are generated by the saw blade when cutting a roof, immediately notify the officer in command. Also, when searching inside a building that you suspect is of noncombustible construction, use a pike pole to push up a ceiling tile, and use a flashlight to the determine the roof or floor support system. Firefighters are the eyes and ears of the incident commander. The chief is depending on firefighters' and company officers' reports of dangers inside a burning building.

Size-up

The cheaply built "taxpayer" of yesteryear was ordinary construction with an inherent defect—a common roof space that allowed fire to spread rapidly over all the stores once flame extends to the roof space. At present, the new taxpayer is also a low-cost building. It is noncombustible construction—the so-called steel building. There may or may not be a fire spread problem caused by a combustible common roof space; however, with noncombustible construction, there is a roof and floor steel bar joist system that may fail within 5–10 minutes of fire exposure. Remember, the new taxpayer problem is not fire spread; it is collapse.

A firefighter's size-up of a burning building should consider both the content and the structure. There are two fire loads (fuels) inside a building that determine the intensity of a fire. The combustible content—the furnishings and material stored inside the building is one type of fuel. The other fuel may be from the structure—the walls, floors, roof, and structural elements, such as columns and girders.

Content Hazards

In ordinary-constructed brick-and-joist buildings, both the content and the structure determine the severity of a fire. In some structures, like heavy timber mill buildings (type IV construction), the combustible parts of the structure—such as timber floors, roof, columns, and girders—present the major portion of the combustible fuel. In a noncombustible building, the content presents the most serious fire hazard. Only the roof covering is a structural fuel load to consider in a size-up. What is stored inside the building and how much are the major size-up questions to be answered at a noncombustible building fire.

Over the years, as businesses come and go, the occupancy changes. Sometimes the content—that is, the fire loading—changes for the worse. The major factor in the death of four firefighters in the Brackenridge, Pennsylvania, fire was the change in occupancy from low-hazard automobile dealership to high-hazard furniture refinishing and storage occupancy.

There are three designations of content hazard inside a building: low hazard, medium hazard, and high hazard. Noncombustible concrete and steel construction without protective fire-retarding material covering steel columns and girders is designed for low fire loading. The furnishing and storage inside an unprotected steel building should be low fire hazard. When a noncombustible building built to contain low-hazard content changes to high hazard, further fire protection should be added to the building. Without additional protection of the steel structure, there could be a fire and heat generation beyond the building's design capacity. The building may collapse quickly during the high-hazard fire. Whenever a fire inspector discovers an occupancy change, the building department and the fire department must conduct another inspection to evaluate the fire protection.

There are certain occupancy types that are considered low hazard, such as offices, banks, and schools. However, if the quantity of combustible material inside such a building becomes excessive or flammable liquid is introduced, the occupancy is no longer low hazard, and the fire protection of the noncombustible structure must be upgraded. Thus, you can have a high-hazard office, bank, or school storage room containing tons of papers, desks, and computers or flammable liquids. Moreover, you can even have a high-hazard schoolroom if flammable liquids are introduced to the subject matter. Recommended changes in fire protection to accompany and change in hazard from low to high include a fire-retarding covering on the steel, the installation of automatic sprinklers, and subdivision of rooms into smaller areas so that firefighters using hose streams can extinguish a fire.

The following classification system of content hazards is widely used (Source: *National Fire Protection Handbook of Fire Protection*):

- ***Low hazard.*** The occupancy (content) when consumed by fire does not exceed an average of 100,000 BTUs of potential heat per square foot. Examples: offices, restaurants, hotels, hospitals, schools, museums, and libraries.

- ***Moderate hazard.*** The occupancy (content) when consumed by fire on average generates between 100,000 and 200,000 BTUs of potential heat per square foot. Examples: retails shops, factories, and workshops.

- ***High hazard.*** The occupancy (content) when consumed by fire generates on average between 200,000 and 400,000 BTUs per square foot. Examples: warehouses and bulk storage buildings.

Protecting Steel

There are three common methods of protecting steel. They are encasement, direct application, and membrane ceiling.

Encasement

There is a method of filling tubular steel with water. However, it is rarely used anymore owing to cost. Builders most often used the encasement method before World War II. Steel was encased with one or two inches of masonry or plasterboard.

Membrane ceiling

The membrane method of fire retarding is another common low-cost method of protecting II noncombustible lightweight steel buildings. The membrane system of fire protecting steel is a suspended ceiling. A suspended ceiling divides the occupied space below from the roof support steel above by a ceiling barrier. A suspended ceiling with a fire-retarding ceiling panel acts as a one-hour fire barrier to protect the steel from a fire in the occupancy below. For the membrane ceiling to be effective, however, the ceiling panels have to be firmly in place. Fire and heat may spread through the ceiling to the steel roof or floor and cause it to fail if all the panels are not in place correctly.

To be an effective fire barrier, the lighting fixtures in the ceiling must be fitted with a fire-retarding frame, and there should be no air-conditioning ducts penetrating the ceiling. Finally, all the ceiling panels must be firmly in place for the membrane fire-retarding effect to be effective and protect the steel roof or floor tresses above.

Fluffy spray-on (direct application)

The direct method of protecting steel structures became popular after World War II owing to its speed of application and low cost. Direct application entails spraying a fire-retarding mineral fiber (fluffy spray-on) or liquid masonry product directly on the steel. The fluffy spray-on is cheaper and faster than the application of concrete or terracotta encasement. A lightweight asbestos (banned today) or mineral fiber is sprayed on steel to protect it from fire. A vermiculite or volcanic rock or mineral wool is mixed in a liquid and sprayed on the steel to provide fire retarding. This method of fluffy spray-on fire protection of steel has been fought by the fire service since its introduction because of the following problems:

- The steel is not prepared properly to allow the spray-on material to stick properly
- The spray-on slurry (mixture of vermiculite and liquid) is often not mixed properly
- Workers do not apply the spray-on material evenly
- Other workers performing subsequent tasks nearby easily remove the critically important fire protection (fig. 15–6)

The exact thickness of the fluffy spray-on has been recently brought into question after the collapse of the World Trade Center towers. The thickness of the fully spray-on was first three-quarters of an inch thick. Then, after tests in the 1980s, the thickness of the fluffy spray-on was increased to 1½-inch thickness. The thickness of the 1½-inch fluffy spray-on was said to provide fire-retarding protection to the steel bar joists supporting the floors for two hours. During an investigation after 9/11, no fire-testing documentation was found to justify the ¾-inch thickness or 1½-inch thickness to provide a two-hour fire rating. The fluffy spray-on fire retarding was difficult to stick to the steel round bar web members. In 2004, the FDNY prohibited the use of open web steel joists in nonresidential high-rise buildings until appropriate fireproofing standards are developed and promulgated.

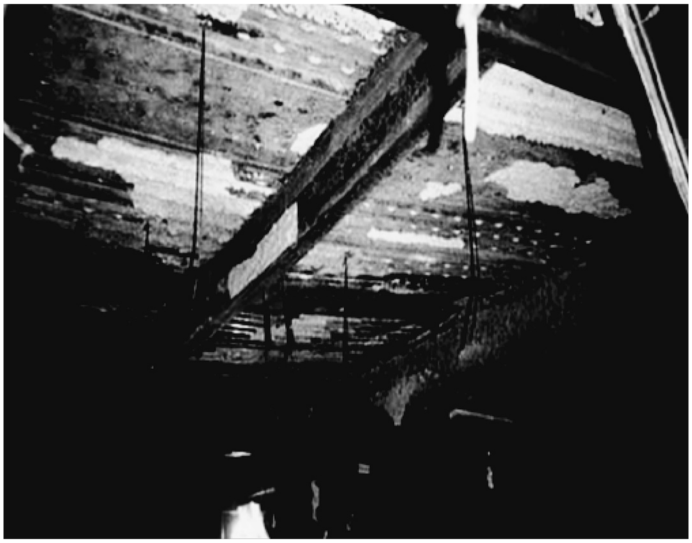


Fig. 15–6. Fluffy spray-on fire retarding can be removed from steel by air movement in a plenum (due to an HVAC system) or by subsequent work.

Summary

When fighting a fire in a noncombustible concrete and steel structure, it must be anticipated that roof and floor collapse is a real and distinct possibility. The following key points should be kept in mind when fighting noncombustible building fires:

- An unprotected lightweight steel bar joist can fail within 5–10 minutes of fire exposure.
- The experience gained by a fire officers over the years in assessing the stability of a solid wood beam roof during a fire cannot be used today to predict the stability of a steel roof or floor.
- Open unprotected steel web bar joists will fail more rapidly during a fire than will solid wood 3-inch-by-12-inch beams spaced 16 inches on center.
- It is very important for firefighters to keep abreast of the construction and occupancy changes that are never ending in building construction and design. Knowledge of construction and content of a building means safety in firefighting.
- The century-old fire furnace testing used by the construction industry to rate steel fire resistance is questionable. The furnace tests only small samples. There is no full-scale testing that simulates an actual fire. For example, the National Institute of Standards and Technology 9/11 study revealed that of a 17-foot piece steel and concrete floor passed the required fire resistance test, but a 35-foot piece of the same steel and concrete failed. Size matters when it comes to fire testing. In the World Trade Center, they used 60-foot unsupported steel floor supports. Testing is for fire resistance ratings. There is no testing for collapse owing to flames and heat when a new floor assembly is fire tested.
- The fire service should take a closer look at firefighting strategy using an aggressive interior attack for long periods in lightweight steel–constructed buildings. Today, firefighters are sent into burning buildings to operate for four or five hours, when the buildings have fire-rated floors of one or two hours and the collapse potential is unknown.
- The fire service must conduct more prefire inspections of new and renovated buildings. Every construction site should be visited, so that fire preplans can be drawn up. These inspections must consider unsafe large open floor designs and dangerous lightweight construction materials such as the steel bar joist truss (and lightweight wood trusses). Fire preplans must emphasize defensive methods of firefighting to compensate for the new and unusual building designs and material. This defensive firefighting must replace the too-often-used offensive firefighting tactics when necessary.

16 HIGH-RISE OFFICE BUILDING FIRES

The standard big city fire department relies on a macro response of 50–100 firefighters to attack a high-rise office-building fire. However, most fire departments do not have that response capability. Small and medium-sized fire departments have high-rise buildings in their communities, but must use a micro firefighting strategy to combat a high-rise fire with limited resources. The incident commander of a small fire department with limited manpower must have a strategy that is different from a large urban fire department. Every day, small fire departments successfully extinguish fires in high-rise office buildings. This chapter outlines a strategy that they can use.

Locating the Fire

After establishing a command post—in the lobby, or in front of the building, or in a command vehicle several blocks away—the first action that the incident commander must take is to determine the location of the fire (fig. 16–1). The floor, apartment, or office suite and room containing the fire, must be determined by firefighters before a firefighting strategy is started. You cannot always identify the fire floor from the street at a high-rise office building. Because of darkness or the height of the building, counting the stories up to the fire will take too long, and a miscount of the floor issuing smoke from a window is probable. Some building signs identify the street-level floor as the ground floor and the second floor as the first. It is critically important for the

Fig. 16–1. Locating the fire is an essential part of a successful strategy at high-rise office building fires.

incident commander and the operations officer, up on the fire floor, to be talking about the same fire floor location; otherwise, the fire will be a disaster. Furthermore, in most high-rise buildings, there is no floor 13; it goes from 12 to 14.

To locate a fire, a search team is sent up to the reported fire floor before a hose team is committed. Before you can determine the floor on which to establish the operations post, the floors of search and rescue above a fire and the areas for the staging of personnel and equipment on the fire floor must be confirmed. In a commercial building, the floor given to the responding firefighters from the dispatcher must be checked with the person in charge of the premises. If there is no one in charge, the reported fire floor must be checked against the alarm panel in the lobby, if there is one present. The floor reported to the dispatcher and given to the first-arriving companies over the radio must match the floor known by the person in charge and/or the floor of fire or smoke indicated on the alarm panel. If they do not match or several floors have been reported, assume that the lowest floor given is the fire floor, and begin your search there. Firefighters have been taken to a flaming fire floor in an elevator because the fire floor was not determined before beginning the search.

The Use of Elevators

If the fire is below the seventh floor, walk up to a fire instead of using an elevator. It is safer. A malfunctioning elevator can take firefighters up to the fire floor even when operating in firefighter service. If elevators have an elevator recall (phase I) system, use it. Bring all elevators down to the lobby. Search each car for unconscious victims. Check the elevator floor indicator to see that all elevator cars have descended to the lobby and that none are stuck in the shaft on a floor above or below the fire.

When using an elevator to send up a search team to locate the exact fire floor, the search team should take the elevator two or more floors below the reported fire floor (fig. 16–2). This is done because there could be a mistake in the reported floor received from the dispatcher. People looking out windows, seeing smoke that is actually rising from a floor below, sometimes mistakenly give their floor as

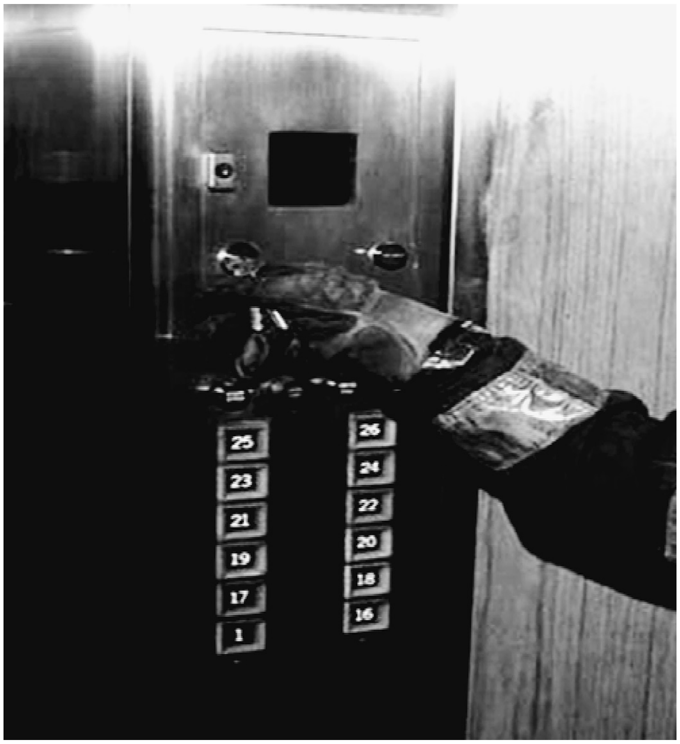


Fig. 16–2. The officer should select the floor destination of the elevator two floors below the fire.

the floor of fire origin. Thus, if you take the elevator only one floor below the fire, you could become trapped in the elevator on the actual fire floor. Remember that an elevator is a dangerous confined space during a fire. If there are several elevators, use the one that has a firefighter service (phase II) system.

An important action when using an elevator at a high-rise fire is to return it to the lobby for reinforcements after taking it to the fire. Do not keep the elevator unattended at the fire. Have a firefighter return it to the lobby. If there are sufficient firefighters on the scene, assign one to operate the elevator during the entire operation. The firefighter operating an elevator should do so continuously throughout the fire. Precautions must be taken in case it malfunctions.

To improve elevator safety, the firefighter operating the elevator must be equipped with a portable radio to request help. A set of forcible-entry tools must be kept in the elevator in case the car becomes stuck and the firefighter has to force a way out of the car and shaft. During each ascent, the controls—even in phase II service—must be checked. Stop the car every several floors to determine whether the controls respond to your command. If the elevator does not stop at an intermediate floor after you set the key controls to do so, assume that it has malfunctioned. Abandon the elevator car and notify the officer in command. Another elevator car or the stairs must then be used by firefighters.

As stated above, during a high-rise fire, one firefighter should be assigned to run an elevator. After the fire floor is confirmed, the elevator is used to take firefighters up to the staging area and must never be left unattended. When there is no need for the elevator during the fire, it should be brought down to the lobby. The firefighter operating the elevator must be equipped with a portable radio. When firefighters require this elevator to pick them up on the upper floor or intermediate floors, they should contact the (firefighter) elevator operator by radio. When large numbers of firefighters arrive at the command post from the apparatus staging area, the firefighter operating the elevator should be instructed by the incident commander to take firefighters and equipment up to personnel and equipment staging (two or three floors below the fire). This elevator should never go up to the fire floor, nor should it go to a floor above a fire when the blaze is not under control.

When firefighters are assigned above an uncontrolled high-rise fire, they should use an aerial ladder or climb the evacuation stairway. They sometimes may use another elevator in a blind shaft—that is, one that does not have an opening to the fire floor. For example, a 30-story building may have two banks of elevators; one bank serves floors 1 to 17, and the other houses an express car to floor 18 that then serves each floor up to 30. If fire breaks out on the 15th floor and it is critical to get firefighters above the fire for life saving, the incident commander could order the use of the bank of elevators that serves floors 18–30 to reach the floors above the fire.

Caution must be used when using a blind shaft to go above a fire. A master stream shooting water in a window striking the elevator shaft wall can collapse the enclosure wall of a blind elevator shaft. Going above a fire in a high-rise building is extremely dangerous. It should be attempted only when there is a confirmed life hazard or when the fire is under control. Three Philadelphia firefighters died while searching above a fire in the Meridian Plaza building fire.

Assignment of Firefighters

At a high-rise fire, there may be more telephone requests for help and more areas to send firefighters than there are firefighters available. A priority of firefighting and rescue assignments must be determined and directed by the incident commander. The highest priority must be to extinguish the fire. If firefighters stop the flame spread and they stop the fire and smoke spread, they will save most lives by these actions. Thus, the first attack hose line extinguishing the fire is the single most important lifesaving action that an incident commander can direct. After the fire location has been determined by the initial search team sent up to investigate, the following tasks should be directed:

Assemble a hose team of one supervisor and four firefighters and send them up to attack the fire. To extinguish a fire in a high-rise office or residential building, a minimum of one supervisor and four firefighters are required. You may have to stretch or carry hose up to a standpipe. In a large fire department such as the FDNY, two engine companies are needed to assemble a high-rise hose attack team of four firefighters. Your fire department may need three or four companies to team up, forming a team of one supervisor and four firefighters. The most important action at a fire in a big building is to get the first attack hose line in position. Most high-rise fires are extinguished by the first attack hose team. If you use the standpipe system, use the largest-diameter hose available and take four hose lengths; buildings with standpipe systems require four lengths. You get only one chance to extinguish a high-rise fire, so you don't want to stretch short. Building codes allow a point in a room to be 125 feet from a standpipe riser, and this does not include turns owing to partition walls. Connect the hose to the standpipe outlet on the floor below the fire. For safety reasons, never connect hose to a standpipe outlet in a hallway or stairway that is located on the same floor as the fire. In case the fire spreads out into the hallway or stairway, firefighters may retreat to the floor below the fire and still control the hose. Use a solid stream nozzle, because the window venting required for a fog nozzle stream may not be feasible if the widows are above the reach of ladders. Venting windows is not recommended owing to the unpredictable wind movements inside the building caused by the stack effect and falling glass danger to people in the street. Most times, a high-rise fire is put out by the first hose line, or it quickly becomes a major alarm. Also, remember that most occupants will be saved if you extinguish the fire. Getting the first attack hose line in place and discharging water on the fire is the most important lifesaving action of a high-rise firefighting strategy. A second hose team should be sent up to the fire, to stretch a backup hose. They connect to the standpipe outlet two floors below the fire, or if conditions permit, on the same floor as the fire.

- When more firefighters become available, send them up in teams of two to perform search and rescue. The first team should be sent up to the fire floor with the first hose team. This search-and-rescue team should search for people closest to the fire and assist people down the stairs.

- The next group of firefighters available at the command post is sent as a search-and-rescue team to the floor above the fire.

- Another search-and-rescue team may be sent to ventilate the roof and the top floor. Primary venting should consist of opening roof scuttle covers and stair bulkhead doors and skylights. Venting the top of stairways expels smoke in the stairs and prevents it from banking down on the top floor. The firefighters assigned to primary venting should use an aerial ladder to gain access to the roof if possible. Several aerial ladders should respond to a high-rise fire. An aerial ladder can be used for roof access and venting; an aerial can be used for rescuing people trapped at windows, and an aerial ladder may be used to stop autoexposure with a master stream. If the aerial ladder does not reach the roof and the building has several stairways, use a stairway not used by the attack hose team. This is because the stairway used by the hose attack team will fill up with smoke, and if firefighters go above the fire, they will be trapped. Warning: Not all stairs go to the roof. Some dead-end on a floor below the roof, and other stairs lead to a mechanical equipment room. If a stairway does not go to the roof, the firefighters can open the stair door to the top floor and vent (open) the top-floor windows. Keys to open windows are sometimes available at the lobby desk. Do not break windows unless the incident commander confirms there are no persons in the street who could be injured by falling glass. Check the floor plans at the lobby command desk to determine which stair leads to the roof before sending a team of firefighters to the roof for venting. This team should go to the top floor by way of a smoke-free stairway. If there are not smoke-free stairs, do not go above the fire. Notify the command chief of this decision and await further orders. People escaping a high-rise fire sometimes mistakenly attempt to go up to the roof. If the stairs are filled up with heat and smoke, they will be found trapped and unconscious in the smoke-filled stairs near the roof level. After the fire is extinguished and conditions permit, all the stairs should be searched. After the fire has been extinguished and it is safe, the roof team may have to walk up a smoke-filled stairway with masks to search for trapped people in the stairs and to vent the stairs at roof level. The objective is to release pent-up heat and smoke. This should be attempted only if ladders do not reach the roof and only after the fire has been extinguished. Portable ladders may be used at a high-rise fire to provide access to firefighters and an evacuation route for occupants. Ground ladders placed at the first- and second-floors windows can be used in similar fashion when the lobby of the building is blocked and cannot be used for entrance or evacuation.

Stairway Firefighting and Evacuation

After the first-arriving firefighters locate the exact location of the fire and notify the incident commander of this, they should also inform the chief if there are two or more stairways in the building and report which will be used to advance the hose (i.e., as the designated attack stairway). The incident commander should designate the stairways for fire attack and for evacuation. The fire officer at the lobby desk will then direct the building manager to announce over the public-address system which stairway people should use to evacuate the building.

Hose Attack

The hose team advances to the fire from the designated attack stairway. When the door from the stairway to the occupancy is open, this stairway will fill up with smoke, so it cannot be used by firefighters to search floors above the fire. The other stairway, designated the evacuation stairway, must be used to go above a fire. All firefighters searching floors above the fire floor should use the evacuation stairway. The door to the fire from the evacuation stairway to the public hallway or office occupancy should not be opened. A firefighter may be assigned to ensure that the door from the designated evacuation stairway is never opened on the fire floor. If this door is opened, smoke will enter the stairway. Firefighters and people above the fire will be trapped in the smoke-filled stairway. Keeping this door closed prevents smoke and heat from entering the stairwell. People assisted down from the floors above the fire should be taken down this smoke-free stairway.

Evacuation of Occupants

If one of the two stairways in a high-rise office building is a smoke-proof tower, this should be designated the evacuation stairway. A smoke-proof tower has an intermediate vestibule containing a smoke shaft which is designed to draw smoke into the vestibule shaft and away from the stair enclosure. A smoke-proof tower should not be used for hose line attack because the smoke shaft located in the vestibule can act as a chimney and draw heat and smoke into the stairway. If the smoke-proof tower is used to connect hose and advance on the fire, smoke will be drawn into the path of the advancing firefighters.

Communications

To communicate lifesaving messages during a high-rise fire, the department portable radios must transmit properly. Radio messages must transmit from the command post to the roof and from the command post to the lowest cellar. Also, there must be a public-address system. This public-address system must allow messages from the lobby to every floor and stair enclosure. A public-address system must exist in all high-rise buildings to instruct occupants as to where the proper stairs are and how and when to use them. A public-address system is needed to tell occupant when not to enter a stairway that the fire department is using, because it will fill up with smoke. Sometimes the public-address system is used to tell occupants not to leave their apartments or the office floor. Sometimes it is safer to remain inside an apartment or on an office floor than to enter a smoke-filled hallway or stairway.

Radio Transmissions

Fire department portable radios often fail at high-rise fires owing to height or the steel and concrete in the structure. Five substitutes for properly operating portable radios at high-rise fires may be attempted:

- Set up the command post outside the building, in the street, instead of in the lobby.
- Move a lobby command post near the elevators. This can sometimes improve communications.
- Set up a relay communications system on intermediate floors in the building and use a relay system to transmit messages between command and operations at the fire.

- If a cross-band repeater radio is available, use it. This radio transmits signals on a triangular path: from lobby command; outside, to the command post in the street; then up to the operations post. The radio signal using the cross-band repeater bypasses all the steel and concrete of the building.
- If a cell phone is available to the lobby sector command and operation sector command, this can be used.
- Stretch a hardwired system with earphones and a transmitter mouthpiece at each end.

All of these are poor substitutes for properly operating fire department portable radios. These substitutes are complex to use during emergency situations, they often fail, they take time to put into operation, and some allow only person-to-person communications. A cluster-type communications system, where the incident commander can hear and transmit to all personnel is critical to fight a high-rise building fire. If a tall or large-area building is being constructed in your community, test your portable radios. They should have transmission capability from cellar to roof and from one end of the building to the other. If not, an antenna should be installed in the high-rise to enhance your department's radios.

Water Supply

At some high-rise building fires, the fire floor operations report to the command post that there is insufficient water pressure for the hose stream. There are several strategies that an incident commander of a high-rise building fire can employ to improve water pressure to the hose stream. One action is to order an increase in pump pressure. A general rule of thumb for pump pressure at a high-rise standpipe system is 150 pounds per square inch (psi) plus 5 pounds additional pressure for each floor above the street level. Fire on the 10th floor would require 200 psi of pump pressure to supply a hose stream with a solid-bore nozzle.

Another action the officer in command can take to increase pressure is to order a second hose line stretched from the pumper to the supply inlet. This will increase water volume and pressure by reducing friction loss in the supply hose stretch from the pumper to the siamese inlet. If the high-rise building has two siamese connections that are cross-connected, supply both of them with two large-diameter hose lines.

A third strategy to increase pressure to an attack hose line is to determine whether the standpipe system has a manual fire pump. Activating the pump can boost pressure in the standpipe. If after starting portable booster pumps, there is still insufficient water pressure on the upper floor, send a firefighter up the stairs to ensure that the valves of the standpipe system are in the proper position. All standpipe outlet valves, except the one supplying the attack hose line, should be closed; all sector outside stem and yoke (OS&Y) valves should be open. Sector valves are located in the basement and at every 150 feet. Sector valves are sometimes shut down during repairs and inadvertently not reopened.

Pressure-reducing valves (PRVs) should be removed from the standpipe outlet valve supplying the attack team hose lines (fig. 16–3). The valve opening should have been flushed to remove debris before connecting the hose. If available, a pressure gauge should be attached between the outlet and the hose line.

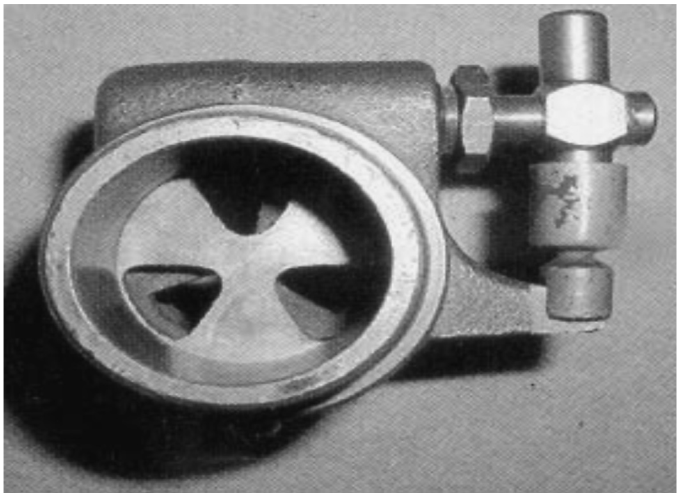


Fig. 16–3. Removal of the pressure-reducing valve.

The standpipe control valve should be opened until pressure on the nozzle is sufficient. If the firefighters do not have a pressure gauge designed for the standpipe outlet, the water pressure and the volume supplied to the nozzle from the standpipe can be controlled by a firefighter opening and closing the handle on the standpipe control valve, depending on radio reports from the officer in charge of the hose stream.

Standpipes and Sprinklers

Some high-rise buildings have both standpipe and sprinkler systems. During a serious fire, the supply of the sprinkler system may be overlooked. At some fires, supply hose is stretched from the pumper to the standpipe, but not to the sprinkler siamese. The officer in charge of a high-rise fire should always determine whether the building has a standpipe and/or a sprinkler system; if it has one or both, make sure a supply hose has been stretched to all siamese inlet. A sprinkler system is more effective than a hose team of firefighters. However, the standpipe should receive the first supply line to protect firefighters. The second supply line is stretched to supply the sprinkler.

HVAC Systems

HVAC systems can spread fire and smoke during a large building fire, so the incident commander should order it shut down. Often the HVAC system shuts down automatically when a smoke detector is activated. However, because this is not always the case, on arrival, order the building personnel to shut it down, to be sure. The fire service must never forget the lesson of the high-rise fire at the MGM Grand, in Nevada, in which an HVAC system pumped smoke through the hotel killing 85 people. Nor should the fire service ever forget the First Interstate Bank building fire in Los Angeles, in which fire spread from the 12th floor to the 27th floor through an air-conditioning shaft in an HVAC system.

An HVAC system houses shafts and ducts that puncture holes in walls, floors, and partitions. An HVAC system can make a honeycomb of holes and voids in a high-rise building, through which fire, smoke, and heat can spread. Some HVAC systems are required by law to have smoke detectors in the return shafts; if smoke is detected in a return duct, the HVAC system shuts down automatically. Many HVAC systems, however, do not have such smoke detectors, so at a high-rise fire, to be safe, order the person in charge of the building to ensure that the HVAC system is shut down. Don't depend on the smoke detector.

Delegation of Command

At many high rise fires, there is a lack of command staff at the fire. Because of the large area involved, the large number of people and firefighters at the scene, the dangers presented by a high-rise fire, there must be an increase in the command staff. You cannot employ the same number of commanders at a high-rise fire that you would employ at a low-rise fire. At a low-rise, two commanders—the incident commander outside and an operations commander inside—are all that is required.

The incident management system recognizes the need for a command staff at a large fire or emergency. For example, if four command officers and a command chief respond on the macro response assignment to a high-rise fire, they could be assigned as follows:

- The first-arriving incident commander should go to the lobby and be given the function of lobby command. A lobby command officer sizes up the building's construction, the fire protection systems and occupancy life hazard. This officer is in charge until the arrival of a higher-ranking officer. The lobby commander is not the operations officer who is sent up to the fire floor. Neither will the lobby commander be the incident commander for long. A criticism made by the National Institute of Standards and Technology, of the emergency responders at the World Trade Center tower fires was that by having the command post inside the lobby it reduced the *situation awareness* of the incident commanders. The size-up by the incident commanders from inside the lobby was not as good as the size-up of the incoming responding fire officers sizing up the fire from outside the towers during the response. A lesson reinforced from 9/11 is that at a serious fire, you need a size-up from inside and outside a burning building. The reason why the first-arriving incident commander should go into the lobby of a high-rise is because the lobby area is usually the command center for the building. The fire safety director or building manager will be present here to assist the lobby commander during the initial stages of a fire. Controls for all the building systems are located at this lobby command station. A lobby fire command station may also be at this location and contain important building system controls needed to fight a fire. A fire control station may contain a public-address system, a video display alarm panel, the elevator controls, and telephone and fire alarm communications controls. The initial decisions and orders made by the lobby commander at this location are critical for the success of the firefighting operation until the command chief arrives. For example, the lobby commander conducts the initial size-up of the fire and assigns and coordinates the first-arriving companies. This lobby commander also controls building evacuation and plans and directs the initial stages of fire extinguishment operations. Even if the command post is set up outside the building, the lobby commander is needed to feed information by portable radio about the building systems to the officer in command.
- The second-arriving officer is the operations officer and goes to the floor below the fire. The operations chief directs the fire-extinguishing effort.

- The third-arriving officer takes command of the search-and-rescue sector and operates on the floors above the fire where the life hazards exist. This officer commands the evacuation of trapped occupants.
- The fourth-arriving officer assumes command of the equipment and manpower–staging sector and goes three floors below the fire floor to set up a staging area for personnel, equipment, and medical headquarters and a rehab center at this point.
- When the incident commander arrives, he or she sets up a command post outside, in the street or in a command vehicle several blocks away. If the command post is in the street or in a command vehicle, the information flow at a high-rise fire will be as follows: information about the fire, the building construction, buildings systems, life hazard, and fire protection available will come from the lobby commander to the incident commander. Orders for rescue and firefighting strategy will come from the incident commander and go to the operations post on the floor below the fire.

Sectoring at a big building fire lets the incident commander delegate the command functions of the fire. It also increases the effectiveness of control, supervision, and safety. If the fire is not controlled by the first attack hose team, the incident commander may have to assign sector officers in addition to these four sector commanders. The dispatcher will designate an officer and a parking location for apparatus staging (level II). Also an attack sector officer may have to be sent up to assist the operations officer. This attack officer will operate on the fire floor and assist the operations chief. Also, a medical command sector also may be required, to command a triage area in the lobby, as well as with staging command sector officer.

Search and Rescue

During a large building fire, people in offices or apartments will call 911 or the lobby desk to ask for guidance or assistance. As many as 50–100 messages may be delivered to the officer in charge. These reports will overwhelm the commander; however, they must be must be recorded and acted on when resources on the scene permit. Usually, there are not enough firefighters on the scene to check out each call for help. During the initial stages of the fire, all available firefighters will be engaged in the fire attack and searching for people in the vicinity of the fire and floor above. However, after the fire is extinguished, the locations of every one of the recorded messages must be searched. Additional resources or mutual aid companies may be called to assist in this duty. Fire victims are usually found in the fire area, at windows of the fire floor, in the elevator lobby, in bathrooms, and in hallways and stairways leading from the fire floor up to the roof. When searching after office hours, check with building management to determine location of people in the building who are working late.

Defend-in-Place Strategy

High-rise office fires are fought while most occupants remain in the building. At some fires, it is safer for occupants to remain in the office than enter the smoke-filled hallways and stairways. High-rise office buildings are supposed to be fire-resistive and protect the people who remain inside. Still, the people who remain in a high-rise building during a fire are alone and want guidance. Every big building should be equipped with a public-address system, and this system should be used to guide people inside a high-rise building on fire. The incident commander at a high-rise fire should order a building employee to give the following messages over a public-address system during a fire:

- Notify the people that there is a fire in the building and the fire department is on the scene.
- If fire is in a high-rise fire-resistive residential building, order everyone to stay in their apartments. It is safer in the apartments than in smoke-filled hallways. If the fire is in a high-rise office building and a partial evacuation is the strategy, announce the floors to be evacuated and the stairway to be used. Notify all other people to remain in place. The defend-in-place strategy is used because stairs are not designed to allow all people in a high-rise building to leave at the same time. The stair width considers one floor being evacuated and then the next floor after that. Also, it may take too much time and too many firefighters to conduct a full-scale evacuation of all occupants of a high-rise building.
- When the fire is under control, notify all people in the building. Tell them the fire has been extinguished.

If there is no public-address system and the stairs are not identified by floor number and stair enclosure, no orderly evacuation is possible. When a high-rise building is constructed in your community, the fire department plans inspector should require that there is a public-address system and that the stairs are marked with floor numbers and stair enclosure identification. This stair identification should be on the inside and outside of every door.

Containment of Fire Spread

Sometimes, a high-rise building's construction helps the fire chief by containing the fire for a period. At other times, a building's construction will hurt the chief by letting the fire quickly spread from the point of origin. Incident commanders and fire officers must know the different ways in which fire can spread throughout high-rise construction in order to save lives and reduce the fire damage. Different types of building construction spread fire and smoke in different ways. The following sections give examples of high-rise fire spread:

Autoexposure

Most large buildings use glass as curtain-enclosing walls or access to balconies. Flames lapping out of a large broken glass window and entering a window directly above is the most common avenue of fire spread in high rise building. If conditions permit, companies assigned to search the floor above a fire should close windows, move combustible furnishings away from incoming fire, and stretch a hose from a standpipe (if available) and use it to extinguish spreading fire. Notify the incident commander of the fire spread or extinguishment. In some instances, an aerial master stream may be positioned to stop autoexposure. When using an outside master stream, communication and coordination between the incident commander and the interior commander is necessary, to prevent injury to firefighters advancing an interior hose line.

Curtain wall space

In a modern office building of exterior-glass curtain wall construction, there is a space between the outer edge of the floor slab and the inside of the curtain wall through which fire can spread to the floor above. This small space near the outer window directly above the flaming window on the floor below must be checked for vertical fire spread.

Utility closets

Poke-through holes, pipe shafts, and steel I beams run from the basement to the roof. Doorways of utility closets or enclosed shafts sometimes have louvered openings; flame can spread into a closet and ascend through an entire high-rise building. The area around the pipe or electric cable may not be filled in with fire-stopping as it passes through each floor. When fire spreads into a utility closet pipe or electric shaft or through a plaster partition near a steel I beam, it can break out on a remote floor above or below the fire floor of origin. Firefighters have battled utility closet fires on upper floors and afterwards discovered that the fire started on a lower floor in the utility closet. Conversely, firefighters have extinguished fires on lower floors that spread to a utility closet, poke-through hole, or steel I beam and later determined the fire spread five or six stories above. When fire originates or spreads into a utility closet, check for fire spread on every floor. Flames can drop down the poke-through opening or spread upward to the floors above.

Access stairs

Open stairways between floors are allowed in some office buildings and in duplex apartments. Unprotected stairways provide access to offices or apartments on different floors. These access stairs are a major avenue of fire spread. Any firefighter who discovers an open stairway during a fire must immediately report this to the incident commander, who should ask the building manager whether there are other open stairways in the building.

Floor cracks

Flame can also spread through a steel and concrete floor. Floor construction of corrugated steel deck and concrete sag and crack at the seams of the corrugated steel sheets. Even a small crack can allow flames to spread through the floor. When an uncontrolled fire burns out an entire floor, the ceiling collapses and flames heat the underside of the corrugated steel. The steel beams supporting the corrugated steel sag and warp. The corrugated steel also sags. The concrete floor above the fire cracks open, and flames spread up through the floor. During a prolonged high-rise office-building fire, there are ceiling and floor collapse dangers.

Firefighting Problems

The following are inherent problems of high-rise buildings that a lobby commander should be aware of:

- An eight-year study of major high-rise fires in New York City revealed that elevators fail 30% of the time.

- Firefighters' radios still cannot transmit lifesaving messages in some high-rise building. New radios in use since 9/11 allow commanders to communicate more effectively.
- High-rise buildings are not fire resistive. Smoke and fire can spread from floor to floor. In the 1970s, New York City had a fire that spread two floors in a so-called fire-resistive building; in the 1980s, Los Angeles experienced a fire that spread five floors in a fire-resistive building; and Philadelphia had a high-rise fire that burned nine floors to a crisp, and the building was demolished because it was declared structurally unsound (fig. 16–4).

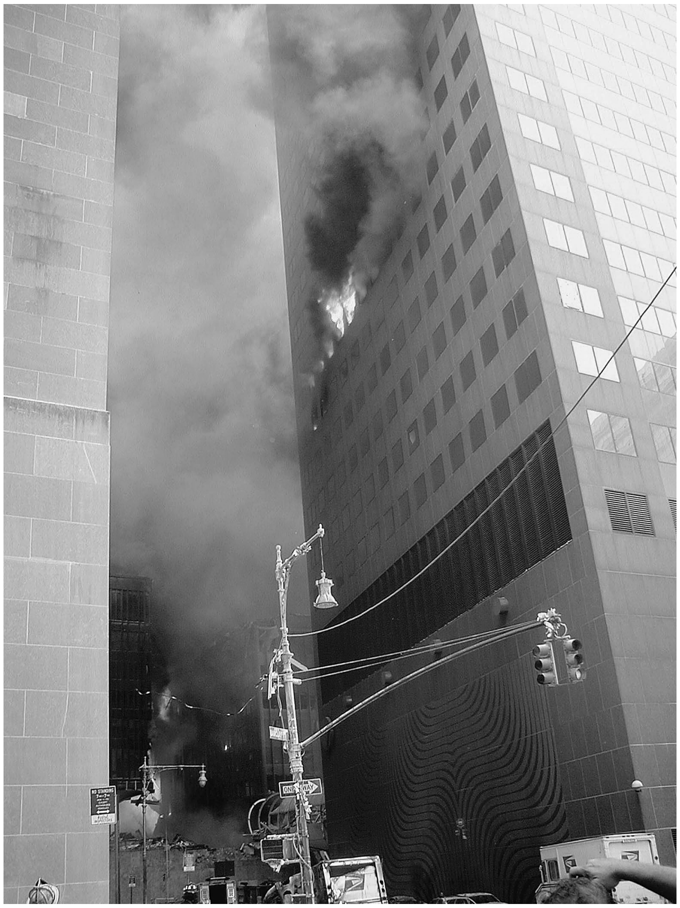


Fig. 16–4. Nine floors burned in this fire-resistive building.

Although the World Trade Center fires were sparked by terrorist-driven airplanes, the buildings survived the impact of the plane crashes. The ensuing fire, not the plane crashes, caused the buildings to collapse. The World Trade Center building fires showed us up close the worst-case scenario of a high-rise fire: uncontrolled fire spreading from floor to floor; people realizing there was no chance of rescue and jumping to their deaths, building collapse, and massive deaths of occupants and firefighters.

The defend-in-place strategy imposed on the fire service by design professionals—architects, engineers, and real estate people—no longer works at high-rise fires. The defend-in-place strategy the design professionals told us to use depends on three factors: first, that the building is fire resistive and will confine a fire to one floor; second, that the firefighters can extinguish a fire in a high-rise building; and third, the occupants will comply with the lobby commander's instructions. All three of these factors on which the defend-in-place strategy is based are no longer true. The buildings are not fire resistive, and they do not confine fire to one floor. The firefighters cannot extinguish a fully involved 10 or 20 thousand square foot floor area; they built rentable floor space too large for manual firefighting. Finally, after the 9/11 World Trade Center disaster, the occupants will no longer listen to the lobby commander's instruction to stay in place while we defend them. However, until the fire service comes up with a better strategy than the current defend in place, the incident commander must use this plan of action at a high-rise fire.

17 GRASS AND BRUSH FIRES

The U.S. Forest Service is considering changing the century-old policy of fire suppression of forest wildfires. The new policy will emphasize thinning the forest and allowing controlled burns to restore the natural state of the nation's forests. Today, according to the U.S. Forest Service, there is a dangerous buildup of fuel in the forest because of current flaws in forest management. They say that the forests are greatly overgrown and have become greater fire hazards. Failure to thin out the forests and misguided efforts to suppress fires even when ignited naturally by lightning strikes deep in federal forests have created an increase in dry, dead vegetation in the forestlands of the country.

This new policy of thinning out the forests and allowing controlled fires is specifically designed for large forest areas. Most of the small woodlands and brush areas of this nation are not part of this policy. Fire departments in rural and suburban areas with brush and woodlands must have a strategy to extinguish brush fires before the flames spread to nearby houses.

There are over 100,000 woodlands in the United States, and several million acres of brush and forest burn each year. Most of these brush and woodland fires occur at the urban/wildland interface. The urban/wildland interface is the place where most people in the nation reside. They may work in the city, but they live in the suburbs and rural areas around the urban centers. Fire departments in suburban and rural communities must still aggressively extinguish brush and woodland fires to protect life and property. Most of the 100,000 annual brush and woodland fires at the urban/wildland interface are smaller than one acre. These so-called brush fires are extinguished by local firefighters using rakes, shovels, axes, portable extinguishers, and small all-terrain firefighting vehicles (fig. 17–1).

When firefighters extinguish these small brush and woodland fires, in addition to saving lives and property, they also prevent them from becoming large conflagrations. It is a fact some large conflagrations at the urban/wildland interface start out as small grass and brush fires. Therefore, incident commanders, even those in urban centers like New York City, must know brush and woodland firefighting strategy.

Brush and woodland firefighting strategy has different objectives than the firefighting

Fig. 17–1. Firefighters must extinguish small grass fires in residential neighborhoods.

strategy for building fires. For example, the strategy for fighting a structure fire is protect life first, then concentrate on fire containment, and finally, protect property protection. However, when fighting a brush and woodland fire, while life safety is still the first priority, property protection is the second priority at a brush or woodland fire, not fire containment. Fire containment becomes a third priority of brush firefighting strategy. At a brush and woodland fire it is possible to save lives and protect property with hose lines but let the fire burn. Moreover, at some large forest fires, it is impossible to contain the blaze. At a structure fire, when an interior attack strategy is used, it is often impossible to protect property without containing the fire.

Definition of a Brush Fire

Burning bushes, shrubs, hedges, grass, thickets, undergrowth, grain fields, and marshland grass are all considered brush fires. These types of vegetation, called brush, grow from 5 to 20 feet high, are clumped together in thick masses, and are considered light fuels. Trees, logs, and wood branches are considered heavy fuels. The light fuels of a brush area are the first to dry out during hot weather. Their finely divided leaves and twig ends are easily ignited. Because of the thick clumps of growth common in brushy vegetation, flames spread with explosive speed. In the case of pine and evergreen shrubs, natural oil on the leaves adds fuel to the brush fire.

Dried-out, burning brush is extremely susceptible to changes of wind and changes in the slope of the ground. Flames of burning brush can reverse direction instantly when the wind changes. Flames of burning brush can suddenly race up the side of a hill or a mountain. Flames of burning brush may flare up explosively or blow 20 feet into the air when fanned by a gust of wind. Firefighters near a brush fire are constantly in danger of being engulfed by a flare-up and burned to death.

Fire Spread of Brush and Woodland Fires

An incident commander's firefighting strategy at a brush fire should be to have firefighters operate around the perimeter of the blaze. Position firefighters upwind and in flanking areas on each side of a fast-moving brush fire. Firefighters should not charge into the center of the fire or try to make a stop at the front or downwind of a brush fire.

Flare-up and blowup are terms used to describe how brush fires burn. Open areas of brush do not burn evenly. Flames do not progress from one side of an open field to the other, nor do they travel up a mountainside in one steady burn. These flames spread in spurts. Fire flares up in one area and then dies down. It may flare up in another distant area and then die down again. It may suddenly race up the side of a mountain. Brush fire spreads erratically and unpredictably. A gust of wind often changes a small ground fire into a sudden, ranging inferno of flaming brush—a flare-up. Firefighters trying to make their way through thick brush are sometimes caught in a flare-up and burned to death. Fires where firefighters are trapped and burned in flare-ups often appear innocent just before the flash. In some instances, firefighters have been killed by flare-up in the mop-up stage of the fire.

Fire Ground Designations of a Brush Fire

At a structure fire, the fire ground designation pinpointing the area around the fire is exposure A, the front of the building; proceeding clockwise, the other sides are designated exposure B, exposure C (the rear of the fire), and exposure D. Fire ground designation is different at a brush fire. An aerial view of most brush fires will reveal a large blackened area with flames at the perimeter edges where fresh shrubs provide fuel. The leading edge of a moving brush fire is called the head of the fire. The opposite side of the head of a brush fire is called the rear. Looking at the fire from the rear of the blackened area, the left side is the left flank; the right side of the blackened area is called the right flank. Inside the large blackened area of a brush fire may be several sections of unburned shrubs or trees. These are called pockets. The blackened area in some instances has what are called fingers. These are strips of long, thin sections of fire that extend outward from the main area of blackened earth. Some distance downwind from the main fire (and the fingers extending therefrom) can be found isolated pockets of small spot fires. These spot fires are caused by airborne burning embers, which the wind has blown ahead of the main fire. These embers land on the vegetation and create patches of fire.

One of the most important size-up factors an incident commander can assess on arrival is the wind direction. Brush fires are wind driven. The incident commander's firefighting strategy should be to attempt to control the head of a brush fire. This can be accomplished by flanking the fire and developing a pincer movement toward the head of the fire from both flanks. Firefighters must not attempt to stop a brush fire by a frontal assault or by a defensive stand at the head (downwind side) of a fire. An onrushing wall of flame at a brush fire can overcome the extinguishing effects of the largest master stream any department can assemble (fig. 17–2).

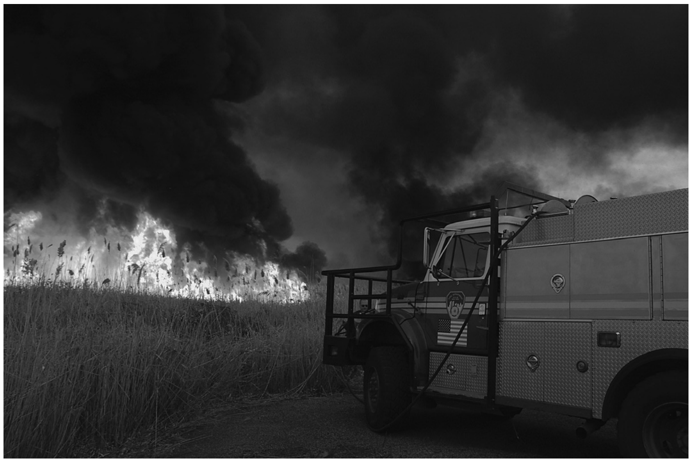


Fig. 17-2. Determining wind direction is one of the most important size-up factors.

Types of Wildfires

There are three classifications of wildfires:

- ***Ground fires.*** Sometimes called bog fires, these are slow-spreading, smoldering fires that burn in dried, decomposed leaves, twigs, or pine needles that have fallen from the trees to the ground.
- ***Brush fires.*** These are fast-moving fires that ignite grass, shrubs, bushes, scrub oak, chaparral, marsh grass (cattails), and grain fields.
- ***Crown fires.*** Most crown fires are caused by the vertical spread of flames of a brush fire. Firefighters using hand tools and a small brush truck cannot extinguish a crown fire or even a large, fast-spreading brush fire.

Firefighting Strategy for Brush Fires

The attack of a brush fire at the head by firefighters using hand tools and portable extinguishers controls 90% of most small blazes. The head of a small brush fire can be approached safely from either the burned-out blackened area or from the flanks of the fire. Positioning firefighters on a road or firebreak area in front of a fast-moving brush fire can be extremely dangerous and should be undertaken only to protect life. An escape route or refuge must be available to firefighters when this strategy is used.

When directing a hose stream on a brush fire, the water stream should be directed at the brush that is burning and not at the flames. Firefighters may also play the hose streams on a house with the purpose of wetting down unburned fuel. Do not waste precious water supply by attempting to break up heat waves. As stated earlier, the strategy of brush firefighting is different from the strategy of structural firefighting. When fighting a brush fire, the strategy is for the safety of lives (including those of the firefighters) to be the first priority and for protection of property to be the second priority during a brush fire. Containment of a large fire may be impossible, and many times, it is poor firefighting strategy to attempt especially when resources are limited. As long as life and property are safe, you do not need to contain the brush fire.

Direct Attack

The safest position from which to attack any brush fire is either flank. If the strategy is to stretch a hose line, the first attack hose should be stretched from the upwind side of the blackened area, alongside a spreading brush fire (fig. 17–3). Firefighters should

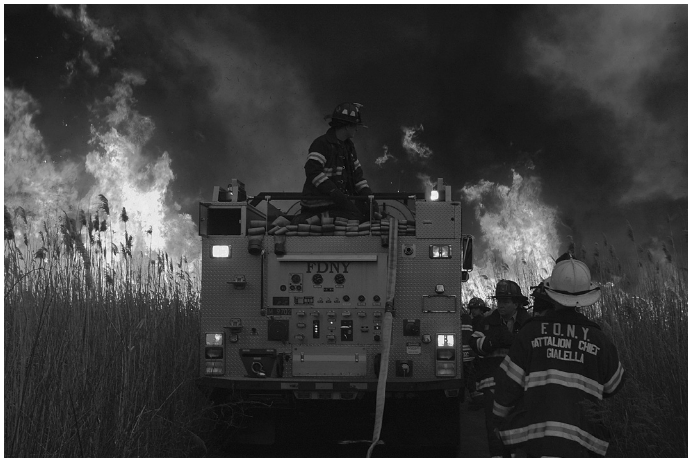


Fig. 17–3. Approach a grass fire from the upwind side.

avoid the head of the spreading fire. If a decision is made to stretch a second hose, this line should be stretched along the other flank. The two hose lines can operate in a pincer strategy and cut off the spreading fire. The hose teams from both sides come together at the head. Another safe area from which to attack the head of a moving brush fire with a hose line is the blackened area. In the blackened area, all the combustible brush has already been consumed by fire.

A safe, close approach to any part of the fire can be obtained from this area. If the wind suddenly changes, there is no fuel to burn; there is no danger that a firefighter will be caught in a flare-up or blowup. However, there are hazards that a firefighter should be aware of when operating a line inside the burned-out area of a brush fire: There is a collapse danger at a brush and woodland fire; sections of burned and decaying tree trunks and falling large branches collapse suddenly, long after a brush fire has been extinguished. Smoke from smoldering ground fire, tree trunks, and leaves permeates the area; the scorched fire ground area will be obscured by a thick haze of smoke, which will reduce visibility and increase the danger of tripping and falling. Heat from the charred earth inside the blackened area of the brush fire increases the danger of heat exhaustion.

Flanking Attack

The firefighting hose team approach to the head of a brush fire from one or both flanks to cut off flames spread is from the upwind side (fig. 17–4).

Aerial ladders and pumpers are limited to areas around a brush fire that have roads. Aerial ladders can be sent to houses in the path of a spreading brush fire. The officer of the ladder company may evacuate people if the brush fire is too severe. Alternatively, if a water supply is ensured and there is a life hazard that cannot be moved, position the ladder to protect a dwelling. If possible, the aerial master stream should be used from a flanking position to attack the oncoming brush fire spread. The water stream should be used to wet down any structure in the path of the fire. Instead of venting a house threatened by an oncoming brush fire, the strategy is no venting. In fact, the building should be closed up. The vent strategy is to seal up all the openings. Close doors, shutters, and windows; remove or shut off air-conditioners; close and cover vents of air-conditioners in walls; and close garage doors.

The interior fire spread of a building in the path of a brush fire occurs in the attic space. Fire from a spreading brush fire will most likely enter the attic by the radiation of heat waves through the roof area. Roof overhangs, open attic windows, roof skylights, and falling hot embers burning in roof gutters are the area of entry by flames. Portable ladders should be placed on

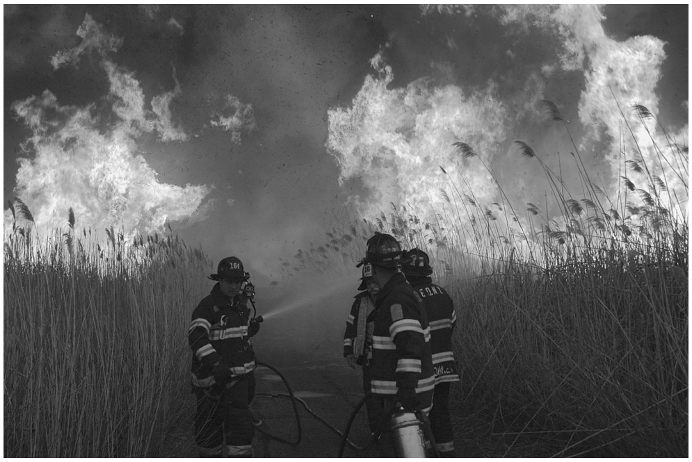


Fig. 17–4. A flanking or pincer firefighting strategy.

rooftops. The ladders will allow firefighters access to roofs. Booster or house hose lines should be used by firefighters on the roof to wet down shingles when an aerial ladder does not have a water source. Firefighters should wet down the roof and the eaves. The interior fire spread problem will occur in the attic. Continually check the attic for fire spread.

In 1995, a large fire in Suffolk County (New York) at the urban/wildland interface spread beyond the control of the firefighting forces of the entire county. The U.S. Forest Service came to their assistance. The Forest Service firefighters responded to Long Island and organized the county firefighters into a multiphase attack on the burning 6,000 acres. The overall firefighting strategy was organized by the U.S. Forest Service, but it was carried out by firefighters of Nassau County and Suffolk County. Incident commanders of all fire departments must know the overall U.S. Forest Service strategy used for wildfire conflagrations. Mutual aid requests from the federal government may require that an incident commander from any fire department responds, becoming an integral part of the overall firefighting strategy. The U.S. Forest Service firefighting strategy used in Suffolk County in 1995 and throughout the nation each year is as follows:

1. Companies with pumpers are limited to areas of brush that contains roads. That is because heavy engines are not designed to enter woods or swamp areas. They can quickly become stuck in soft ground or mud.

2. Firefighters assigned to pumpers are directed to respond to houses threatened by windblown flames of brush and woodland fires. The firefighters on these high-risk missions evacuate people from homes threatened by fire and, in some instances, protect the structures from the oncoming brush fire. Sometimes these firefighters also extinguish blazes inside homes after they are ignited by the spreading brush fire.

3. Other firefighters are assigned to smaller fire trucks that drive through the woods and extinguish spot fires. These hand crews are directed to extinguish small brush fires near the perimeter of the conflagration.

4. Construction companies are brought in to clear woods and brush and create firebreaks with heavy equipment. The heavy equipment removes brush, grass, and dried-out pine needles down to the dirt, so that no fire can pass over the open area. Firebreaks are designed to remove fuel by cutting roadlike strips of clear spaces and possibly stop the spread of fire. The firebreaks cut through the Long Island woods were initially several feet wide and were increased up to the final firebreak of 150 feet wide.

5. Inaccessible wildland preserve forests and remote or dangerous areas where firefighters cannot enter are the general targets of wildfire aircraft. A water-carrying aircraft can drop up to 6,000 gallons of plain water, "wet" water, viscous water, or fire-retardant water. Plain water is capable of extinguishing an ordinary brush, grass, or forest fire. Wet water is plain water with a chemical additive to make it penetrate porous surfaces; the added chemical reduces the surface tension of water, so that when wet water is dropped from an aircraft, it can reach a bog fire or a ground fire that has burrowed below the ground surface. Another type of chemical added to water creates what is called viscous water; viscous water can be dropped from an aircraft on very

hot forest fires where radiation heat may spread fire. The chemical added to viscous water makes it thickened water. There is less runoff, and viscous water sticks and clings more readily to burning fuel. Another chemical (ammonium phosphate or ammonium sulfate) added to aircraft water creates a fire-retardant water. This fire-retardant water has the extinguishing power of water, and it also reduces the possibility that the brush fire will ignite again. U.S. Forest Service aircraft water tankers, when they arrived in Suffolk County, were assigned to drop tons of water and fire-retardant liquids over the remote areas of the large fire where hand crews could not reach.

High-Voltage Electric Wire Hazards

A deadly hazard often found in brush and woodlands is posed by high-voltage towers and electric overhead wires. Ground fires and brush fires sometimes burn beneath and nearby these transmission lines. Live burning wires that have fallen to the ground may be hidden in the grass. Firefighters could step on a fallen wire and be electrocuted. Utility companies warn us that heavy smoke plumes coming in contact with overhead wires can cause phase-to-ground shorts that may injure and kill firefighters. Firefighters should avoid operating hose lines beneath high-voltage wires. Electricity could come in contact with an overhead wire or down wire. Utility companies recommend that firefighters operating hose streams should also remain at least 100 feet from overhead electric lines.

Summary

The priorities for fighting wildfires are different from the priorities for fighting structural fires. Wildfire firefighting priorities are as follows: Protect life first, conserve property second, and contain fire third. When a wildfire does not endanger life or property, sometimes the best strategy is to let it burn and control the direction of spread.

Firefighting strategy should be a direct attack on the head of the brush fire from upwind. An attack on the head of the brush fire can be achieved from along one or both flanks, starting on the upwind side of the fire and from within the blackened area.

Downwind is the most dangerous area of a brush fire. Firefighters should avoid this area unless there is a life hazard. Uphill and upwind is even more dangerous. Firefighters should never descend a hill to attack a brush fire. A fire spreading uphill burns with the same speed and intensity as a fire fanned by a strong wind. The rate of flame spread in a brush fire on a mountainside increases with the steepness of the slope.

A flare-up is a sudden increase of flame from a small ground fire to a large area of blazing brush. A flare-up is similar to a flashover in a structure fire. Firefighters may be surrounded by burning brush when it suddenly flares up. A flare-up may be caused by a gust of wind, a shift in wind direction, a downward current caused by a low-flying helicopter, or a change in the slope of the ground.

Most firefighter injuries and deaths occur in relatively light fuels such as grass, brush, and bushes. Most firefighter injuries and deaths occur during relatively small brush fires or in isolated sectors around the perimeter of larger fires.

18 FIRES IN VACANT BUILDINGS

A mayor in a declining New Jersey community in the 1990s described the urban decay processes. He wanted his town council to declare bankruptcy. He stated that crime was rising, residents were leaving, businesses were moving out, the number of vacant buildings were increasing, and arson fires were on the rise. Vacant buildings are what the fire service calls "fire breeders"—abandoned, derelict buildings that breed arson fires and eventually lead to the destruction of a community. Vacant apartments creates vacant buildings, and vacant buildings create vacant communities.

Urban firestorm was the name used to describe the rapid rise in fires in the Northeast and the Midwest during the 1970s. The urban firestorm was fueled by vacant buildings. As people fled the cities and crime in the 1970s, they left thousands of vacant buildings. When the Bronx was burning, it was in the thousands of empty buildings in the Bronx left behind by the people moving to the Sunbelt. The urban firestorm of the 1970s should have been called an arson/vacant-building firestorm.

The same urban decay process was happening in New York City, Boston, Chicago, Philadelphia, and other large cities during the 1970s. In the '70s, crime was on the rise, and the migration of people and businesses to the Sunbelt arson fires in vacant residential and commercial buildings became the number-one fire problem in the United States. For example, in 1975, New York City responded to 54,000 structural fires, 9,000 of which (18%) were arson fires in vacant buildings. Most of these vacant-building fires were major greater-alarm blazes.

As cities and towns change and people move in and out, vacant and abandoned buildings appear and then disappear. There may not be as many vacant buildings as there were in the 1970s, but there will always be some communities where people leave and vacant buildings appear. As factories close and manufacturing moves overseas, some communities die and vacant buildings appear. The vacant-building fire problem will never go away. Many of today's firefighters are not familiar with the dangers of vacant buildings. Furthermore, some firefighters have forgotten the vacant-building fire hazards. The vacant building is not only a fire breeder but also a firefighter killer (fig. 18–1).

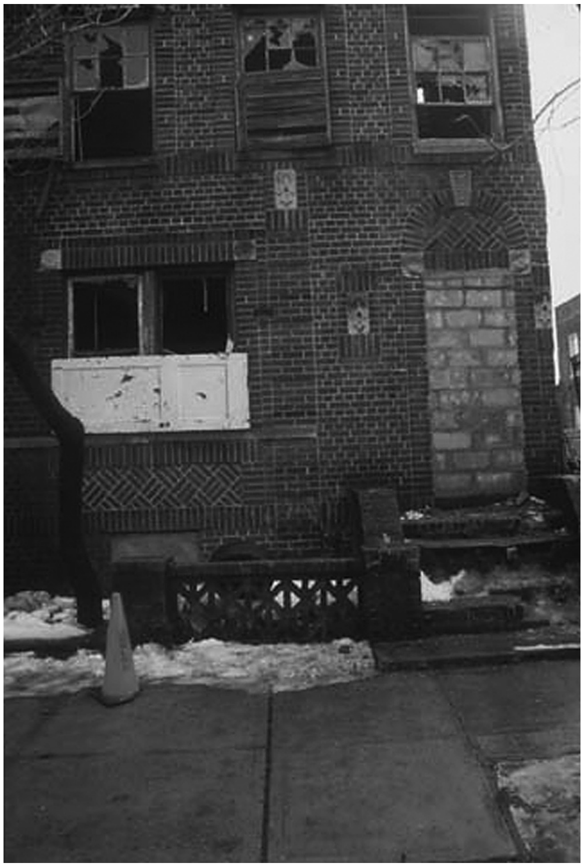


Fig. 18–1. The vacant building where Lieutenant John Clancy died when a floor collapsed.

A vacant building is an easy target for an arsonist for several reasons. First, it provides easy access. An unlocked door or missing and broken windows allow an arsonist to gain entry to start a fire. Second, it provides concealment of the crime. The arsonist can spread the flammable liquid and start the blaze in the unoccupied building hidden from view. Third, there is plenty of fuel in a vacant building. Sometimes, the structure provides the fuel, and at other times, there is clothing, furniture, and stock left in the building after the people leave, which provides combustible material for a fire. Finally, after the arson fire is started, it grows undetected. There is usually a delayed discovery of the fire in a vacant building and it becomes a major-alarm fire. The fire may already control several floors on arrival of the first responders, or it may have spread to adjoining buildings.

A vacant building can experience 10–20 fires in one month. This happens when the building is not sealed up and arsonists have easy access to the inside of a building that is full of rubbish and left-behind content. Most of the fires in vacant building are small and easily extinguished; however, there is the potential for a major fire over a period of time. To prevent multiple fires in a vacant building, it must be boarded up properly to keep out unauthorized people.

Inspecting Vacant Buildings

Vacant buildings require fire department inspection, because experience has shown that this is where fires are going to happen. If there is one vacant building in your community, a fire will probably occur there. Fire department inspections of vacant buildings are different from inspections of occupied buildings. There is no life hazard, and there is not property to safeguard.

The purpose of a vacant-building inspection is to record and document the building as fully vacant and to let fire officers become familiar with the building's interior and any hazardous content left behind. During a fire, when the building is filled with smoke, knowledge of the layout of rooms, stairs, fire escapes, and hazards inside will be important firefighting information. During an inspection, the structural stability and hazards in hallways, stairways, and fire escapes can be assessed. Holes in floors created by scavengers and scrap metal dealers and overhauling at prior fires must be noted. Firefighters are injured and killed during fires inside burning vacant buildings by falling through these floor openings located in hallways, corridors, and stairways leading to the roof areas; trapped by fast-spreading fires; and crushed by collapsing walls and floors. Outside a vacant building, broken fire-escape steps, railings, and ladders; unstable parapet walls; and rotted and weakened floors must be noted.

After an inspection, written notification of the hazards discovered should be sent to nearby fire companies, who respond to a fire in the building. This notice should warn them of hazards discovered. The number of vacant buildings in your community should be monitored, as well as the interior and exterior deterioration. If the number of vacant buildings is increasing in your community, so will the number of fires and so will the number of firefighter injuries. When a large number of vacant buildings starts to appear in your community, the top city officials should be notified, and one of the following recommendations should be made:

- Have the building renovated after finding an occupant for the residence or business
- Have the building demolished
- Have the building boarded up until you decide what to do with it
- Have it burned down in a controlled fire supervised by the local fire departments

In New York City, most of the vacant buildings were residential buildings, and with the help of state and federal government funding in the 1980s and ’90s, they were renovated and reoccupied by people moving into the city. New York City has experienced an explosive increase in its immigrant population, and these vacant abandoned buildings have been reoccupied.

Demolition of vacant buildings is not effective in a built-up urban area. The nearby houses could be weakened by the demolition blast. Also, many people in a community will be against it because they see vacant buildings as a future job resource. Vacant buildings create potential jobs for local residents. Unfortunately, neither funding nor a demand for housing becomes reality, so the buildings remain vacant for many years. Some communities have buildings vacant and deteriorating for decades.

Boarding up vacant buildings until deciding what to do with the building was the strategy used in New York City. In the city, we still have boarded-up vacant buildings, but not as many. However, these boarded up-buildings, vacant for 30 years or more, have become extremely dangerous. The board-up process has prevented intruders in some instances. However, the interiors of these vacant buildings have become so weakened by lack of maintenance, exposure to the elements, and numerous fires that they have become very unstable. After a heavy rainstorm, the boarded-up structures have been known to suddenly collapse; for example, strong winds brought down a vacant 100-year-old frame building in Brooklyn. Demolition workers are often killed and injured when tearing down these deteriorated vacant structures.

Controlled burning of the vacant buildings was never permitted in New York City. However, most of them were eliminated by uncontrolled burning.

Arson

If the city fathers take no action on the vacant building, prepare for the worst. A vacant building is an arsonist's dream (fig. 18–2). Arsonists come in all sizes and shapes. They can be homeless people carelessly starting a fire to keep warm, drug addicts fighting over their next supply, or sick thrill seekers; they can be young children from the neighborhood playing with matches; they can be salvage workers using cutting torches to remove scrap metal from a vacant building; and they can be neighborhood activists protesting the presence of deteriorating vacant buildings in the community. Many times, arsonists are unscrupulous landlords who want the insurance money from a building that cannot be rented or leased.

Fig. 18–2. Vacant buildings breed arson fires.

In the late 1970s, when President Carter announced that the federal government was going to provide billions of dollars to rebuild the Bronx, arson fires dramatically increased. To be eligible for funding, the building had to be completely vacant, and many buildings still had a few people living in partially vacant buildings. This was an incentive to burn the few people out of the buildings. Even before this rebuilding incentive, the arson-for-profit game proceeded as follows; a building owner would sell a worthless partially vacant building to friend for an unrealistic sum. The friend would sell the still-vacant building back to the same previous owner at a higher price. After several months and several sales back and forth, the fire insurance was increased dramatically. Then, the vacant building was torched. Arson reached its peak in New York City in the 1980s.

Fire Spread

A vacant building is dangerous for many different reasons. One reason is progressive fire destruction caused by one fire after another fire. Ten, twenty, or more fires take a toll on a vacant building. Homeless people and scavengers—people removing scrap metal from a vacant building—create the most destruction. Holes in floors of bathrooms, hallways, corridors, stair steps, and stair landings often injure firefighters in a smoky fire. In addition, holes on rooftops, especially those near doorways or scuttle covers, create severe fall hazards to firefighters venting roofs during a smoky fire or at night. More deadly than the fall hazard, these holes and openings let fire and smoke spread rapidly throughout a vacant structure. This unusually rapid fire spread can trap firefighters on upper floors. Doors, windows, and stair railings may be removed. Cast-iron piping is stripped from each bathroom, leaving holes throughout the ceilings of the entire building. Metal, copper roofing, utility pipes, electric wire, fire escapes, and industrial machinery are sometimes removed, creating more structural damage.

When a building is vacant for some time and it is stripped of its interior doors and windows, flame and smoke from an arsonist's fire spread rapidly throughout each floor in the building. There is no compartmentalization left in the vacant building to stop fire or smoke spread. Unheated deteriorating vacant buildings exposed to the elements experience additional hazards. Ceilings and wall plaster coverings have already been stripped from the interior. With the interior sheathing missing, any fire started inside will quickly involve the structural members, such as columns, girders, beams, and trusses, and any fire can cause a rapid collapse.

Vacant buildings left open sometimes become dumping grounds for large amounts of rubbish: used tires, abandoned cars, oil drums, hazardous materials, flammables, and anything that costs money to discard will instead find its way into a vacant building at night. Fuel from previous unsuccessful arson fires or from old industrial processes that took place inside the building before it became vacant may have soaked the floors, creating vapors for explosions, flashover, and rapid development of smoke conditions during a fire.

Size-up

Some incident commanders view a vacant building fire as a training session. But watch out: a closer look reveals a very different story. A vacant building is a dangerous place and presents a complex fire spread problem. A vacant building is more dangerous to firefighters than a fully occupied building. Safety officials tell us workplace disasters happen most often when we do not perceive danger and when we are performing a routine operation. This happens at a fire in a vacant building.

Safety officials also tell us that the first step in risk management is to accurately identity the workplace danger. Only then can we manage the dangers and reduce them. Some fire departments have not identified the vacant building as a firefighting danger. The vacant building must always be considered a dangerous work environment. Today's incident commanders may not know this, or veterans may not have correctly passed this message along to the present generation of fire officers. The lessons learned by incident commanders in the 1970s was that the vacant building is a major-alarm fire, requiring a defensive firefighting strategy using master streams, and that it kills firefighters. Today's firefighters must be reminded of the dangers of vacant buildings.

In December 1999, six Worcester, Massachusetts, firefighters died in a fire in a vacant building. Homeless people started the fire. As is typical of an arson fire, there was a delayed discovery of the fire. Fire and smoke rapidly spread throughout the building. Six firefighters were caught and trapped.

A vacant residential building is dangerous, but a vacant storage building is even more deadly. One lesson learned from this tragedy should be that certain buildings are more dangerous than others. Each year, the annual death statistics show firefighters die battling these three dangerous fires:

- Fires in residential buildings
- Wildland fires
- Store and office fires

However, if you look at the death statistics in terms of firefighter death per fire, instead of total firefighter death, you will see a different picture. Actually, a residential building is not the most dangerous occupancy, even though most firefighters die battling blazes inside them. A 10-year National Fire Protection Association study of firefighter death statistics showing the rate of death reveals the real dangerous occupancies. Vacant buildings and buildings under construction or demolition are considered special-occupancy buildings. Annual statistics show that 4 firefighters die for every 100,000 fires in residential buildings; 8 firefighters die for every 100,000 fires in commercial buildings; and 11 firefighters die for every 100,000 fires in special-occupancy buildings. A vacant building is considered a special-occupancy building. Vacant buildings and buildings under construction or demolition are the most deadly buildings in which to fight a fire.

During the 1960s, '70s, and '80s, firefighters were seriously injured while fighting fires in vacant buildings. For example,

- Six New York City firefighters died when the wall of vacant factory collapsed.
- Nine Boston firefighters died fighting fire in a vacant hotel under renovation.
- A New Jersey firefighter was killed when a fire escape collapsed.
- An intermediate landing of a stairway collapsed, dropping a firefighter to the next landing, which also collapsed.
- A parapet wall collapsed on top of firefighters operating in a tower ladder bucket.
- A battalion chief was trapped on the roof above a fully involved top-floor fire that was due to the absence of fire doors in the vacant building.
- A firefighter fell through a prior roof vent in a top-floor fire and was severely burned.
- On December 1, 1995, Lieutenant John Clancy, FDNY, was killed when a section of floor in a vacant building collapsed beneath him as he entered the burning structure. He fell into the burning cellar. Homeless people had started the fire to keep warm.
- In December 1999, six Worcester, Massachusetts, firefighters died as they were caught and trapped in a spreading fire in a vacant cold storage warehouse (fig. 18–3).

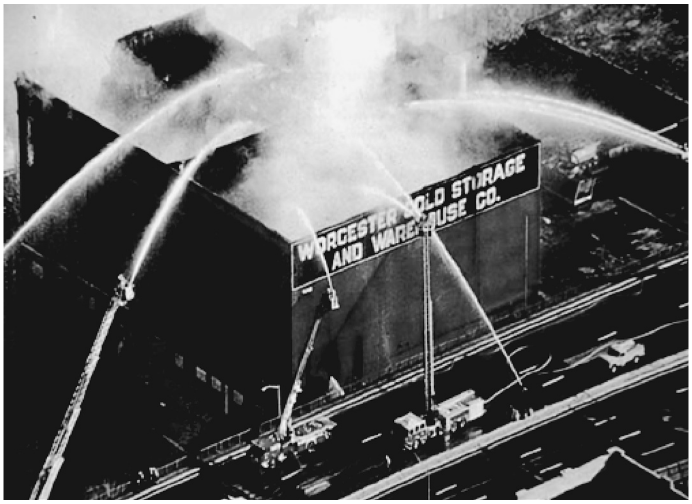


Fig. 18–3. Six Worcester, Massachusetts, firefighters died in this vacant building.

Firefighting Strategy

Size-up

On arrival, the first officer to arrive should size up the fire and the vacant building. If the officer decides the fire should be an outside defensive attack, this information should be announced over the radio to incoming units. This communication should state, "By order of the incident commander, the strategy is a defensive outside attack. No firefighter should enter the building." This announcement will inform all incoming units of the strategy. Everyone responding to the fire will have gotten the word.

Interior attack

If the first-arriving officer decides the fire in the vacant building can be extinguished by an offensive attack, the first line should be taken in the building, and the fire should be extinguished. Next, a backup line should be stretched to protect the firefighters operating the first line and, if needed, to stop vertical fire spread. Portable ladders should be extended to windows on fire floor. These ladders might be used to rescue firefighters suddenly appearing at a window, trapped by the rapid spread of a fire.

Exterior attack

An aerial ladder should be placed in front of the building. This ladder should be raised. It may be used for firefighter access to the roof for stair venting, for rescuing a trapped firefighter suddenly appearing at a flaming window, or for a master stream for a defensive outside firefighting operation if the interior attack fails. The aerial ladder should be supplied with a large-diameter supply line for possible use.

Strategy change

A vacant building fire should be extinguished by one hose line and the backup line, or a defensive operation should be the strategy. There should not be five or six hose lines inside a spreading vacant building fire. The general rule if fire is on two floors and cannot be readily extinguished is that a defensive attack strategy on an empty building should be considered. Most fires in vacant buildings are extinguished by the first attack hose line; otherwise it becomes a major fire operation. When the first attack hose lines do not extinguish the blaze, the incident commander should change the strategy.

At a vacant building where there is an interior attack being waged on a fire, the incident commander should be proactive. Set up master streams around the building to protect exposures, and position them so that they will be ready when supplied with water. Then evaluate the interior attack strategy. If the interior hose line attack does not appear to extinguish the vacant building fire, change the strategy: Notify everyone at the scene; then withdraw firefighters; and after all firefighters are in a safe position, change the strategy from offensive to defensive.

Venting

Venting of a burning vacant building should be limited to the roof skylight scuttle cover and roof bulkhead door opening at the top of the stairway. If the building is open and missing windows and doors, venting the fire and smoke is not a priority. If the building still has windows intact, vent the windows of the fire floor. Coordinate the window venting with the advance of the attack hose line. If the vacant building is boarded up, venting may become a major part of the firefighting strategy. One or two companies may have to be assigned to the venting operation. Smoke and heat building up in the vacant building may be tremendous. Removing bricks, plywood, and sheets of tin from windows and doorways will be a high priority.

Search

There is no life hazard in a vacant building. However, homeless people, who sometimes start these fires, may be found trapped by the fire and smoke in a vacant building. A primary and secondary search in a dangerous vacant building may be delayed until after the fire has been extinguished. A slow, safe, and methodical search can then be performed. Owing to the danger of the vacant building and the low probability of a finding a victim in a vacant building, firefighter safety becomes the primary life hazard. Vacant building dangers are a valid reason for delayed discovery of a fatal fire victim.

Interior fire spread

The interior fire spread problem in a vacant building is severe. Flames may spread through doorways and windows because the normal compartmentalization of an occupied building will be missing. Doors, windows, and sometimes even partitions, which all normally restrict the spread of flames, can be missing. Flames spread up stairways to top floors, autoexposure allows fire spread from window to window, and two or three apartments may contain fire due to broken partition walls between apartments.

A flammable liquid may have been used to start the fire, so fire spread can be explosive. Flashovers, flammable vapor explosions, and natural gas explosions are common in burning vacant buildings. Delayed discovery allows flashover to occur, and flammable vapors are exuded from the fuel used to start an arson fire. Natural gas explosions happen during fires in vacant buildings because the utilities—gas and electric—are rarely shut off even though the building is empty. Sometimes during an arson, fire may spread downward, below firefighters operating a hose line. Delayed ignition of flammable liquids dripping and flowing down a stairway, shaft, or concealed space can suddenly ignite on the floors below, trapping firefighters.

Exterior fire spread

Because the building is unoccupied, when the fire starts, there is no one to call the fire department. There is often a delayed alarm, so fire may be spreading from window to window on arrival. For a vacant town house or garden apartment, the common roof space is a large concealed space and is a common area for an arsonist to start a fire. An arsonist drills a hole in the roof, pours flammable liquid in the space below the roof and above the ceiling, lights a fire, and the entire top floor becomes involved in flames. The arsonist escapes by walking across to the adjoining roof and walking down the stairs.

Check the common roof for concealed fire spread as soon as the fire is extinguished. In vacant unattached buildings, fire spreading out several windows of a delayed-discovery vacant building may spread flames to adjoining buildings across alleys on both sides. When several building are burning on arrival, protect the exposures first and let the vacant building burn. The first attack hose line should be sent to the exposure downwind. Where the smoke and flames are spreading must be checked first. Then, a hose line should protect the upwind exposure. If the vacant building is a row dwelling and the fire is on the top floor, send the first line to the top floor of the downwind exposure. Pull the ceiling of the adjoining building on the side of the building near the vacant building and stop any fire spread collapse danger.

The collapse dangers of a vacant building are many. According to a 10-year study of collapse, floor collapse is the most common type of collapse, followed by roof collapse. The study found three times more firefighters operating below a roof are killed than firefighters operating on top of the roof. If there is a report of a weakened roof, the incident commander should withdraw firefighters operating below the roof, as well as firefighters on top of the roof. Wall collapse is the third-most-common type of collapse at a structure fire. When there is a danger of wall collapse, set up a collapse zone around the burning building.

Suspended ceilings are the fourth common collapse danger at a structure fire. If fire spreads into the space above the ceiling and the ceiling hanger strips are weakened, the ceiling may collapse. When firefighters use a hose stream to extinguish fire in the ceiling space, the weight of the hose stream water can collapse a ceiling. Before entering a store or renovated building where there is a danger of suspended-ceiling collapse, check the ceiling space at the doorway by pulling down a small part of the ceiling with a pike pole. If there is fire or water pouring down, use caution. When a suspended ceiling collapses, the entire framework comes with it. It is the heavy framework of the suspended ceiling that traps firefighters.

When a master stream is used at a fire in a vacant building, the firefighters in the bucket of the aerial ladder should survey the front wall of the burning building and check for cracks and unstable walls surfaces. The parapet, the portion of front wall above the roof, should be surveyed for weakness. Parapet walls have collapsed, showering tons of bricks on firefighters in the bucket of aerial platforms while they are extinguishing fire in vacant buildings. Sometimes the bucket is ripped from the aerial ladder boom owing to the impact of the falling brick.

The master stream should start extinguishing fire at the top-floor windows and work downward, extinguishing fire and checking the building facade for stability as firefighters proceed downward. Before the defensive aerial attack begins, the ladder truck should be placed away from the front wall. When the bucket is raised for fire extinguishing, the firefighters and the bucket should be kept out of the collapse zone. Firefighters up in the bucket operating aerial master streams are in danger of wall collapse, as are firefighters in the street. To keep the bucket away from an unstable wall, firefighters should use the 75–100-foot reach of the master stream and should stay out of the collapse zone.

The incident commander should expect the worst at a fire in a deteriorating burning vacant building. For example, if the strategy is an offensive attack and firefighters are extinguishing fire with interior attack hose streams, realize that a firefighter may suddenly appear at a window, trapped by fire. The incident commander should order raised ground ladders placed to windows on the fire floors. At a defensive outside attack, when one or several master streams are used to extinguish fire in a fully involved burning vacant building, the incident commander should prepare for a multilevel floor collapse and a wall collapse. Firefighters and apparatus should be outside the collapse danger zone or in flanking positions.

What actions can we take when a building in our community becomes vacant, and how can we safeguard the community and responding firefighters from its dangers when the city officials do not address the problem? Here are some suggestions:

- ***Seal up or demolish.*** First, inspect the building. If it is sealed up, that is good. However, if it has been vandalized and is accessible to arsonists, notify the owner to seal up the building. If the owner does not seal up the building, notify the local building department that the structure has become a hazard to the community and request that the building be demolished.
- ***Familiarization inspections.*** During the inspection of a vacant building, firefighters who respond to the area should conduct a familiarization inspection of the interior. Hazards inside the vacant building should be noted and recorded. This information should be transmitted to all adjoining fire companies that respond to the vacant building.
- ***Cyclical inspections.*** If after several months, the building has not been demolished or sealed up, conduct inspections at regular intervals to observe new hazards created by fires, vandals, and salvage workers. Record the hazards and notify all responding firefighters. Reissue a seal-up notice to the owner; if the local government has assumed ownership of the building, issue notices to board up and/or demolish to the local government.
- ***Warning signs.*** When vacant buildings are not sealed up or demolished and have deteriorated over many years, firefighters must protect themselves. Firefighters in New York City have developed a system of marking dangerous vacant buildings (fig. 18–4). These markings near an entrance doorway made by inspecting firefighters are 12-inch squares of reflective yellow paint that glows in the dark and indicates to firefighters the hazards inside the building.

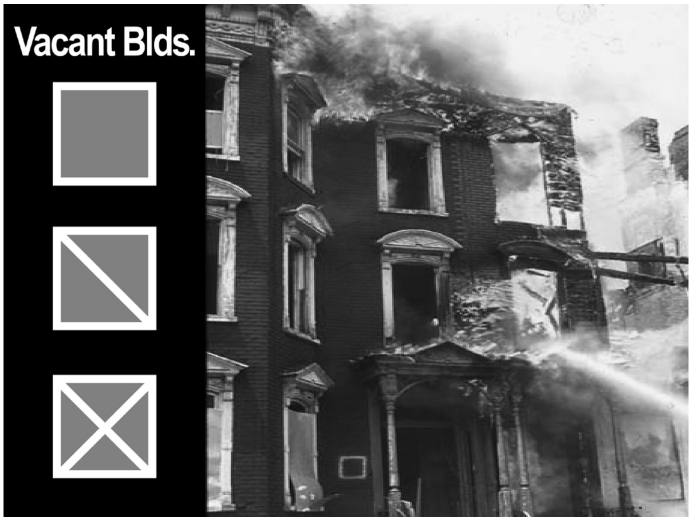


Fig. 18–4. A yellow marking on this building indicates that the building is vacant. One diagonal line in the box indicates that hazards exist in the building. Two diagonal lines in the box indicates that there are several hazards, and an exterior attack strategy may be recommended.

- ***Defensive strategy.*** The presence of a box with an X (skull and crossbones) inside gives the first-arriving incident commander permission to fight the fire from the outside. If it is more efficient and safer to enter and extinguish the fire while it is small, then do so; however, if in the incident commander's judgment, the building and/or the fire size warrants it, an outside defensive attack may be the initial strategy.

- ***Request police assistance.*** When you board up a building, which is the third option for dealing with a vacant building, it will most likely be torn open again by vandals, homeless people, drug addicts, or children. Thus, vacant buildings should be inspected by firefighters on a regular cycle. Orders to reseal the building must be given again and again to the owner or the city, if it has taken ownership of the building. Also, police must be notified to keep people from breaking open a sealed-up vacant building. If the buildings are not resealed or people are not somehow prohibited from entering vacant buildings, there will be a continuous cycle of fire and boarding up over the years.
- ***Defensive fire preplanning.*** Having on file defensive fire preplans of large, vacant commercial buildings can help firefighters prepare for the end of a vacant building, which is sometimes destruction by fire. The detailed defensive prefire strategy is not drawn up for all vacant buildings. There may be too many similar small residential buildings, and for these, a walk-through familiarization inspection is sufficient. However, a firefighting strategy for large, vacant target hazards requires defensive preplanning. The local fire company should draw up a firefighting plan of action for a large, vacant building, such as a storage building, factory, public assembly building, store, or office building. When a defensive preplan is drawn up for a large-area vacant building, the following defensive firefighting strategy should be considered:
  - Apparatus positioning
  - Water supply
  - Defensive master stream positioning
  - Exposure protection strategy
  - Mutual aid considerations
  - Collapse dangers

19

TERRORISM EXPLOSIONS

The *Wall Street Journa*l stated the first responders at a terrorist incident would serve as miners' canaries. That is, firefighters and police officers would collapse like the caged birds once carried by miners, to signal the presence of something exceptionally dangerous. Bringing in the Department of Homeland Security, the U.S. army, and the National Guard will help, but the toughest job will fall to local fire and police departments, which are still not prepared.

Terrorism was defined by the Federal Bureau of Investigation (FBI) as an unlawful act of force or violence against a person or property with the intent to coerce or intimidate a government or people for a political or social purpose. Recently, though, there has been a change in the objective of the terrorist acts. In the past, the objective of terrorists was to bring attention to a political or social cause by committing a destructive act. Today, however, the objective is to kill. Terrorists wants to kill as many men, women, and children as possible. Unfortunately, firefighters and police are sometimes the people killed.

Also according to the FBI, the terror weapons used most often are bombs and improvised explosive devices (IEDs). The fire service will be part of the first-response team that responds to terrorist acts. In this time of the War on Terror, everyone will be asked to contribute. Police officers, transit employees, and building managers have all taken steps to prepare for another attack. What about your fire department? We may be called into action by federal, state, and local officials to perform duties that we have not been trained to accomplish. Until better training comes to the fire service, we will have to improvise actions at an incident where there is a suspected IED and mold some of our firefighting strategy to fit terrorism incidents. The following sections provide firefighting strategies that can be used when responding to acts of terrorism. Defensive firefighting procedures can be used when responding to a suspected IED (fig. 19–1).

IEDs

What is the difference between a bomb and an IED? A bomb goes into an airplane; a bullet goes into a gun; an artillery shell goes into cannon; and a grenade goes on a soldier's belt. An IED is not a bomb, though; it is any type of explosive material

Fig. 19–1. A defensive firefighting operation is the initial strategy at a terrorist attack.

that can be stuffed into a bag, pipe, bottle, can, package, or 55-gallon drum.

A fire response to an explosion caused by an IED can result when teenage boys try to make a pipe bomb. At one incident, boys filled up a section of pipe with match heads. While screwing the last end of the cap onto the pipe, the compression caused the bomb to explode. Both boys had serious injuries. Most terrorist IEDs are much more deadly; these have been built and used by urban rioters and domestic or international enemies of the United States and are used to kill or injure people.

IEDs are the number-one weapon of terrorists. This is the most probable response fire and police will encounter. Therefore, the fire service must have a strategy for fire department operation in case an IED is suspected or has already exploded, causing a fire and collapse.

Firefighters arriving first at a terrorist bomb or IED incident will be required to take lifesaving action. Police sometimes request the assistance of firefighters when searching for bombs or IEDs. In the past, when searching for an IED, local officials and police have requested the fire department's assistance for evacuation, forcible-entry, collapse search-and-rescue, and firefighting operations after the IED explodes. The firefighting strategies described in this chapter can be used for fire operations where IEDs are suspected or have detonated.

Assisting Police at a Bomb Incident

When a call is sent to the fire department for assistance with a suspected bomb incident, only one chief and a pumper should respond. This small response offers the advantages of better control, coordination, and safety at an incident where there is a real danger of explosion, collapse, and fire. The chief should report to the police commander and first get a briefing about the specifics of the incident—who, what, when, where, why, and how. Next, the incident commander must size up the construction occupancy and available fire protection. For example, the building's contents and the construction must be considered to estimate the possible fire and type of collapse. The height of surrounding exposures must be observed. Adjacent higher buildings will be at greater risk during a fire than low buildings or buildings of equal size. Water supplies, sprinklers, standpipes, and hydrants to be used should be identified. A staging area must be upwind, uphill, and out of the range for an explosion and possible contamination from a dirty bomb. Prearranged locations and spaces for apparatus placement in the danger area must also be determined during the size up, as well as the best location to position an aerial platform for master stream use.

Hydrants for Pumper Hookups

Access for apparatus and firefighters must be maintained by police. A triage center should be set up by medical personnel at staging. The potential for large numbers of injuries from the IED explosion and biological, nuclear, or chemical contamination exist at such an incident. Finally, the fire chief determines the number of fire companies to call to the scene.

Based on the size-up, the incident commander should order a specific number of responding fire companies to stage at the designated safe location, out of the explosive danger zone, and not report to the command post until called for. Responding units should be notified, before responding, that department radios and cell phones may trigger a bomb explosion, so mobile radios and phones of incoming units should be shut off 300 feet from the suspected bomb area.

Decision Making

At a terrorist incident where federal, state, and local officials are present, the fire department is going to be requested to perform duties, some of which we have not been trained to perform; moreover, some requests may place firefighters in unusually high-risk situations. Firefighters may work with a federal, state, or local official or police officers; however, firefighters operating at terror incidents should operate under the supervision of a fire officer at all times. All decisions that place firefighters at risk at a terror incident should be approved by the fire commander at the scene.

Many government officials from federal, state, and local governments who respond to fires and emergencies today have no experience in operating at life and death emergencies. They may order firefighters to take unreasonable risks for a political reason, not a life and death object. Most nonuniformed officials responding to emergency scenes are elected or political appointees, and they do not understand life-and-death decision making at emergency operations: Life safety is the first priority—and this includes the life safety of the first responders. Incident stabilization is a second priority, and property protection is the last goal of the first responder's actions. If the fire officer in command determines the actions requested of firefighters are too dangerous, the incident commander has a legal and moral responsibility to notify the federal, state, or local official in charge of this opinion.

Forcible Entry

If a police or public official requests that firefighters force entry to premises where there is a suspected IED, the team fire officer must first size-up the entire doorway. In some instances, doors are booby-trapped. Any vibration on the door could trigger a blast. If an alternative approach is possible, the fire officer should suggest placing a ladder at a window and allowing the police to gain entry through the window. A rabbit tool should be used to force the door. This creates less vibration and is quicker. As soon as the forced entry is accomplished, all firefighters should be withdrawn to safety.

If the team fire officer determines that it is safe to force entry and the police have any type of protective body armor, the firefighters performing forcible entry should borrow and wear this protection.

Any firefighter asked to enter police lines must be equipped with the same standard protective equipment used by police at such an incident, such as helmet, face shield, bulletproof vest, and shield of armor. If this equipment is cannot be obtained, full protective clothing plus SCBA and eye shields should be worn by firefighters. All other firefighters at the scene should use distance and shielding for protection from a possible explosion. Control of all firefighters at the scene is a must during an IED response.

Evacuating Nearby Buildings

Firefighters may be requested to assist police in evacuating adjoining buildings near a bomb. Firefighters should protect exposures and evacuate people from nearby structures outside police lines. When a bomb explodes, one of the greatest causes of death and injury is flying glass. Windows may blow out to the street. All firefighters inside and outside during an evacuation procedure should be ordered to have eye shields in place. During an explosion, jagged glass pieces will fly through the air with hurricane force. All protective clothing—especially eye shields—should be used to protect firefighters.

The minimum number of firefighters should be used to evacuate a nearby building, and firefighters in teams should operate with a supervising team fire officer. The strategy at the scene of a suspected bomb is still life safety first, and this includes firefighters. Public officials and some police commanders may not be aware that incident stabilization is the second priority at any emergency scene, and property protection comes third, according to fire service guidelines. The incident commander may have to remind public officials who appear to be unfamiliar with emergency rescue operation principles.

Evacuating people near a suspected hidden bomb site is different from evacuating people from a burning building. The evacuation procedures are based on the fact that police may expand the bomb search and eventually have to search this area after the people leave. First, before the evacuation starts, a specific stairway should be designated for evacuation. People leaving the building should be requested to leave by way of this exit. A prior search of the entire stairway—including lobby and stair corridor—should then be conducted before the evacuation commences. There should be large holding areas where people leaving the building should be instructed go once outside. People should not linger outside the building; this will slow the evacuation.

During the evacuation, people asked to leave a building should be told to take all belongings, clothing, and packages with them, so that there will be fewer items to search for the hidden explosives. Also, people should be directed to leave open their desk drawers and lockers. This will reduce the property damage; desk locks and closet doors will not have to be broken by bomb searchers. Windows and doors should remain open. These openings will become vents and release destructive pressures during an explosion. Leave the lights on: the searches may not get to the area until darkness, so this measure will improve their visibility. Shut off office machines such as computers, fax machines, and coffee makers. The noise from electric and mechanical devices may be mistaken for a bomb.

Buildings are not automatically evacuated when there is a reported bomb nearby. Sometimes the terrorist gives a report that there is a bomb in a truck, in a parked car, on a windowsill, or in the street. If a bomb is reported to be outside, it may be safer to keep the people inside the building and take them to the basement or an interior windowless room. When the decision is made to evacuate people from a building, they may be taken out a rear doorway if the suspected bomb is placed in the front of the building.

The decision to evacuate or not to evacuate is not always the incident commander's. It is the decision of the building manager whether to evacuate the occupants. For example, if there is an anonymous telephone call that a bomb has been placed in a building, it is the decision of a building manager or a school principal whether to order the building evacuated. The fire commander at the scene may assist in the evacuation. However, if a building manager or a school official asks an incident commander, "Chief, what do you think? Should we evacuate the building?" the fire officer may offer advice, but it should be made clear that the decision whether to evacuate occupants is that of the person in charge of the building.

For example, there was an incident in which a bomb was reported in a school and the principal decided not to evacuate the students. She was initially criticized by parents. Then she defended her actions by stating that the caller was not familiar with the school, so she decided the call was a prank. In her defense, she reminded the parents of a reported incident in which a school was evacuated and the shooter was waiting outside and killed several children with a rifle.

In another case, an incident commander ordered a building evacuated because of a reported bomb placement. After the evacuation and the search were completed, no bomb had been found. The local government was sued by one of the companies whose employees were ordered to leave the building. The company's CEO claimed that because the building was evacuated and some employees did not come back to work after the bomb search proved negative, the company lost money. He further stated that the loss was due to the order given to evacuate the building during the bomb search.

Firefighting Strategy

Firefighters should respond to a reported IED explosion scene from the upwind side of the incident and from uphill, so that any contaminated runoff water from hose streams does not spread to firefighters and apparatus. The initial fire attack at a terrorist bomb blast site is a defensive operation using master streams equipped with large-diameter nozzles. A nozzle of 1½ inch or 1¾ inch diameter from a deck pipe or aerial stream, supplied by large-diameter hose with 100 pounds nozzle pressure, can produce a stream that reaches 90–100 feet. These large-diameter streams from portable deluge nozzles, deck pipes, snorkels, and/or aerial master streams can provide safety to firefighters by leaving a large distance between them and the contaminated explosive area. Increasing the distance from the danger area, limiting the time of entry near the danger area, and shielding (taking cover behind fire apparatus and buildings) may be the only protection against a blast and windblown contamination from a dirty bomb IED (fig. 19–2). If after arriving at the scene, there is a report of another explosion or chemical, biological, or nuclear contamination, firefighters should be withdrawn.

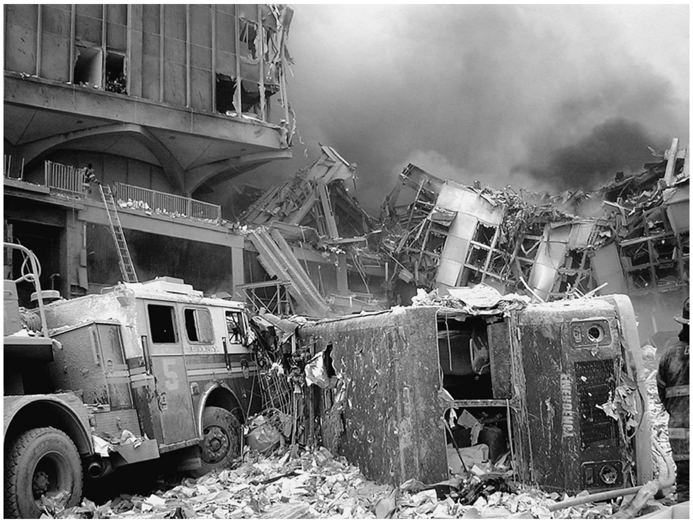


Fig. 19–2. Limiting exposure time, increasing distance from the incident, and taking cover behind shielding objects are defensive tactics used by firefighters responding to a terror attack.

Whenever firefighters are committed to firefighting operations at a suspected IED explosion, the incident commander should consider the possibility that the bomb might be contaminated by nuclear, biological, or chemical materials. In addition to the incident commander's ordering firefighters to use the protection of time, distance, and shielding, a verification of the surrounding area for contamination or reports of a dirty bomb should be obtained from officials on the scene and the dispatcher. The priorities of a terrorist response are life safety first—and this includes the lives of the responding firefighters. Chemical experts should be called to the scene to analyze the atmosphere. If contamination of the area has been confirmed, a hazardous material incident should be declared.

If firefighters must continue to operate due to life saving factors, the time firefighters spend at the explosion site should be controlled and limited by timing and rotating members. All potentially exposed firefighters should be quarantined and sent to a decontamination area.

Lifesaving searches

The strategy of limiting exposure time and using the shielding of nearby buildings and fire apparatus provides admittedly poor protection at a terrorist incident; however, this is all that is available to many fire departments today. Interior assignments should be for rescue only. Firefighters assigned into teams should be equipped with all available protective equipment. In addition, they must have radios, masks, forcible-entry hydraulic tools, portable extinguishers, and monitoring and sensing devices to detect chemical, nuclear, or biological hazards.

The protection of time can be used by limiting firefighters' exposure risks in a danger area. For example, the incident commander can order a time limit of 15 minutes or less for operations at the scene of an outside explosion and/or a search in a low-rise building and a search time of 45 minutes or less in a high-rise building. Of this total high-rise exposure time, only 15 minutes is for entry on the floor of the terror incident; 30 minutes is provided as reflex time getting to the high-rise incident floor and returning to the command post. Also, the use of protective HAZMAT suits and shielding provided by protective equipment, along with monitoring devices for the detection of radioactive and chemical materials, should be required for all firefighters entering a contaminated area.

Master streams operating at terror incidents should not have firefighters positioned at the tip of the ladder. For example, aerial platforms with fixed nozzles can be raised at low angles to increase distance from the blast. They may be operated by firefighters on the turntable. Ground-based portable deluge nozzles should be tied to a substantial object and left unattended.

If there is no life hazard and it is suspected that the fire and explosion is the result of a dirty bomb, let the fire burn. More contamination may result from hose stream runoff and fire kept smoldering by a defensive attack. A standard procedure for a fire in a pesticide plant is to let the fire burn; this may be the preferred tactic for a dirty bomb that has caused a fire.

Collapse search and rescue

The aftereffects of any type of explosion, including a terrorist's IED, will be smoke, fire, dead and injured bystanders, and people trapped inside a collapsed burning building, calling for help. The first responders to an explosion should first quickly size up the scene and follow the collapse rescue plan. The collapse rescue plan has five steps:

1. Safety size-up
2. Removal of surface victims
3. Search of voids and crevices for trapped victims
4. Tunneling and trenching
5. General rubble removal

However, only the first three steps should be carried out immediately at an explosion and collapse due to a terrorist devise.

The first action at a explosion site where a terrorist device is suspected should be to size up the entire scene. Conditions at the rear or sides could be worse than the front of the bombed-out building site. Omit the survey on the downwind side of the collapse area if there is the danger of windblown contamination from a dirty bomb. The objective of the safety size-up is to look for trapped victims, spreading fire, parts of the building that are in danger of secondary collapse, and avenues of access into the demolished building. The size-up should also note the location of any sprinkler siamese inlets serving the building. An indirect attack on a collapsed burning building by use of master streams and sprinkler systems should be the first choice for fire suppression during an explosion due to a terrorist device.

On arrival of the first responders after a terrorist's bomb detonates, bystanders will have already rushed to the aid of surface victims. It will be a chaotic scene. These civilian rescuers and the victims buried in the rubble may become contaminated by a biological, nuclear, or chemical contaminant. Fire lines must be set up, and everyone at the scene must be segregated and restricted from leaving the scene.

Set up a HAZMAT-type operating procedure. Rope off the hot area (contaminated), the warm area (for segregation and decontamination), and the cold area (safe), and request that police restrict entry and exit from all three areas at the HAZMAT scene. The incident commander's preliminary report should state the following clearly: "This is a possible terrorist bomb, and fire responders should report to a staging area uphill and upwind and not report to the command post." Hazmat and decontamination units should be called to the scene. Civilians and rescuers will have already pulled surface victims from the collapse rubble. Rescuers and victims both may be contaminated and should be segregated and not allowed to leave.

During the size-up, one of the first actions of the incident commander should be to shut off the utilities serving buildings in the explosion site. If possible the gas, electric, and water supply to the bombed-out building should be shut off. Leaking gas can cause another explosion;

electric wires in the collapse rubble may ignite the leaking gas. If the electricity is not shut off, it can electrocute victims and rescuers who are digging in the rubble. Shutting off the water supply to the collapsed building many prevent the drowning of people who have taken refuge in the below-grade areas. Utility companies should be called to the scene to assist in this important lifesaving action.

Collapse search-and-rescue operations will include only the first three steps of a collapse rescue plan: safety size-up, removal of surface victims, and search of voids and crevices for trapped victims. The fourth and fifth steps, tunneling and trenching and general rubble removal, are not carried out at a collapse and explosion due to a terrorist device until the site is declared safe from another explosion and/or contamination. Prior experience at collapse search-and-rescue operations has shown that 75% of the survivors will be saved by the application of the first three steps of the collapse search-and-rescue plan. After these three actions are completed at a collapsed-building operation, the risks (i.e., danger to firefighters) exceed the benefits of finding live victims. At a terrorist incident, the danger is even greater. The final collapse search-and-rescue steps should be delayed until the site is declared free of chemical, biological, and nuclear contamination. A second bomb could be located near a command post or on a roadway used to transport victims to a hospital.

Firefighter Safety during a Police Bomb Search

On arrival in response to a suspected bomb placement and on arrival, firefighters will be requested to stand by for orders while police are searching. The incident commander should ensure that firefighters take cover. Sometimes a bomb is placed in a parked car or truck at the sidewalk around the building. Other times the IED is placed on a windowsill. Consequently, firefighters outside will be exposed to the blast. While police are searching for a bomb, firefighters should be positioned a safe distance away from the building. The incident commander should order firefighters to position apparatus around the corners of the building, out of the direct blast danger zone. Firefighters should not be positioned near glass windows that may shatter during an explosion. Taking cover behind a building or around a corner will protect firefighters from the direct blast and shock waves of an explosion. However, shock waves of an explosion and flying shrapnel can ricochet, bouncing off buildings and traveling around corners; thus, protective equipment (especially eye protection) should be worn at all times, even when out of direct path of the bomb area.

Firefighters generally are not requested to search for IEDs; however, during these early, undefined stages in the War on Terror, if there are insufficient police officers on the scene and the fire department has personnel available with protective equipment, the incident commander from the fire department may be requested by community leaders and/or federal, state, or local officials to have the firefighters search for a terrorist's biological, nuclear, chemical, or explosive device. IED searching by untrained firefighters is not recommended. However, if it is a life-and-death situation and many community members' lives are at risk, considering the priorities of incident management during size-up of the situation: life safety of community residents first, incident stabilization second, and property protection third. The fire commander might be ordered to commit firefighters to search for a terrorist device or to assist police in the search. The following are some guidelines for IED searching that you may use.

Bomb-seeking strategy

Searching for IEDs is different from fire searching. Searching begins outside the building. First, vehicles parked in the street around the building are examined. Owners are requested to move vehicles. Any vehicle not identified by a local resident and not moved must be considered a potential vehicle bomb. Next, the outside sidewalk around the perimeter of the building is examined for the bomb. Windowsills on the first floor are often the site of a package bomb. Then the building's interior is searched, starting in the cellar and working upward. Pay attention to areas where a bomber could gain access inside the building and easily place an explosive package and set a timing device unnoticed. Bathrooms, stairways, refuse containers, storage areas, and supply closets are places in which a bomb may be hidden.

Most important, if a suspected bomb is discovered, do not touch or disturb it. Note the location, floor, and room. Report this to the incident commander. Do not use portable radios that may trigger an explosion during search.

According to the manual *Emergency Response to Terrorism* (pp. 4–39), the following are indicators of a bomb's presence:

- Abandoned vehicles that do not appear to belong in the area
- Strong chemical odors
- Any unusual or out-of-place container
- Obvious bomb-making pieces such as blasting caps, wire, or clock timers
- Any unusual device attached to a pressured or flammable container or cylinder
- Unusual looking or misplaced mailing containers leaking oil or having wire poking out
- Bags hanging on hooks inside restroom stalls

Firefighters sometimes accidentally come upon stockpiles of stored IEDs during fire prevention inspection of buildings and when searching buildings for fires and alarm malfunctions. Firefighters should be able to identify a bomb. Being able to identify a bomb may save a live. When any of the following explosive devices are discovered, the police bomb squad should be immediately notified; the device should not be disturbed until the people in the area have been evacuated.

Explosive material placed in a pipe (pipe bomb). Explosive material is packed into a pipe and capped on both ends. Nails or sharp objects may be attached to the outside of the pipe. This is a fragment bomb; it kills and injures by exploding pieces of flying metal. Do not touch a pipe bomb discovered at a fire; pipe bombs are sensitive.

Explosive materials placed into a bottle (bottle bomb). The most common bottle IED is called a Molotov cocktail, named after a Russian government official. It was a World War II antitank weapon and is the weapon of choice of urban terrorists acting out at civil disturbances. This type of IED can be identified by a liquid-filled bottle with a piece of cloth at the opening. A bottle filled with gasoline and sulfuric acid, capped and wrapped in a sock soaked with potassium chlorate and sugar, is a common IED. When thrown, the bottle breaks, and the mixing of the sulfuric acid and the potassium chlorate causes the explosion and resulting fire. Bottle bombs have been discovered on roofs of multiple-dwelling residences by firefighters conducting building inspections. They are thrown off the roof onto police and fire trucks in the streets below.

Explosive material placed into a small can with a spark plug (car bomb). This type of IED is a canister usually placed inside the motor compartment of an automobile. The lid of the canister is closed and sealed. This type of IED would be identified by examining a car's engine and observing the spark plugs. A spark plug is installed through this sealed canister lid. The wire of spark plug 1 is removed from the engine spark plug and is attached to the bomb spark plug. When the car is started, the bomb explodes. The car bomb is sometimes used by organized crime to assassinate a mobster. The car bomb is also used in revenge killings by deranged persons.

Explosive material placed into a backpack (satchel bomb). This is a satchel or bomb IED. Several sticks of dynamite placed in a shoulder-strap bag with one or two small liquid propane cylinders can create a tremendous explosion and fire. Any type of bag left unattended must be considered a potential IED. This type of bomb can be thrown into a window or left in a crowded area. The cylinder of liquid natural gas is added to create a fireball during the explosion. A satchel bomb can be thrown, planted on a train, or hung on a hook inside a restroom stall or inside a locker in a train or bus station. Eleven people where killed and 86 were injured at LaGuardia Airport in 1975 by a satchel bomb placed in a locker.

Explosive material placed in a postal package (mail bomb). The so-called mail bomb is most often found in small packages sent through the mail. A letter (package) bomb often kills or injures the wrong person. The spouse, relative, or coworker of the intended victim may open the mail bomb. A mail bomb can sometimes be identified by excessive weight, oil stains, lopsided or uneven packaging, excessive postage or foreign mail, airmail or special-delivery indicators, or a missing return address. The Unabomber, Ted Kaczynski, killed 3 and injured 17 over 23 years by sending package bombs to people associated with airlines, universities, and corporations.

Explosive material placed in a flashlight (flashlight bomb). The explosive material can be inserted where the flashlight batteries would normally fit. The flashlight IED can be carried or placed in a bag and not create suspicion. This type of IED can be identified only by examining the batteries of the flashlight. When searching baggage, battery compartments should be checked to ensure that explosives have not been stowed in place of batteries.

The same action of not disturbing the explosive and notifying a supervisor applies whenever firefighters are working inside a burning building and discover a military grenade, artillery shell, or bullets. At one sad incident several years ago that involved a weapons discovery in the Bronx, this procedure was not followed. Firefighters were overhauling after a bedroom fire and discovered a gun beneath a mattress. The firefighter finding the gun jokingly picked up the gun and pointed it at another firefighter, and it accidentally discharged, shooting the firefighter in the heart and killing him instantly.

Explosive materials used to make IEDs. There are three classifications of explosives used to make IEDs: high explosives, low explosives, and blasting agents. Don't let this classification scheme fool you. There is no difference between high explosives or low explosives and blasting agents when they explode. The explosive power of all three agents is the same. The only difference is the degree of heat or shock it takes to detonate each one. Low explosives take more heat and more shock to detonate than high explosives; blasting agents (e.g., ammonium nitrate is classified as a blasting agent by the Department of Transportation) takes more heat and shock to explode than low explosives; however, it is just as powerful as a high explosive when it is detonated. Blasting agents were used at the Oklahoma City terrorist bombing and at the first World Trade Center attack in 1993. (Jet fuel was the explosive material used by the 9/11 terrorist hijackers.)

It is also very important for firefighters to realize that the fire service considers all three—high explosives, low explosives, and blasting agents—to be explosive materials. The fire service and the National Fire Protection Association's standard operating procedure for fighting fires involving such materials is as follows: "No attempt should be made to fight a fire involving explosive materials." Firefighters may attempt to control a fire that is spreading toward a structure that contains explosive material; however, if the fire spread appears unstoppable or the flames have already involved the structure or magazine containing the explosives, firefighters should not attempt to fight the fire. Firefighters should evacuate the people in the area and themselves to a distance of at least 2,000 feet (610 meters).

Explosion effects

The explosion from an IED is the same as that from any explosive material. An explosion is a violent expansion of gas. Accompanying an explosive blast are heat, flames, noise, shock waves, and shrapnel. When an explosion happens, first there are powerful shock waves from the explosion. These shock waves spread outward, upward, and down into the ground. Carried along with the shock waves are fragments of the explosive container. Then the blast creates secondary fragments: glass, windows, doors, and partition walls of nearby buildings. As a result, there may be a vacuum—causing an implosion.

Glass and parts of building facades collapse down into the street. One of the major causes of injury during an explosion is cuts and lacerations. An explosion creates a hurricane of broken window glass. Cuts and lacerations will be the major injury type. Eye and face protection is very important. Even when first responders start operations after an explosion, there will still be a severe danger of falling objects. Glass and parts of the facade will fall from the upper floors of damaged buildings. Glass shards, parapet walls, and curtain wall facing will fall to the street. Head protection will be very important during search and rescue. The only person killed during the search and rescue at the Oklahoma City bombing was a nurse named Rebecca Anderson. She was struck on the head by an object falling from an upper floor.

Recommendations

Fire departments should identify terrorist targets in the community. Then, preplans should be established. Some possible targets are as follows:

- Places of transportation, such as train stations, airports, bridges, tunnels, and ports
- Sports facilities
- Utility plants and fuel pipelines
- Government buildings
- Finance centers

The Department of Homeland Security should train police, fire, and local officials in a unified incident command system and hold interagency operations at these terror targets for prebomb and postbomb blast procedures, such as location of water supply, stretching hose line, and supplying sprinklers and standpipes. Preplan the positions for a command post, and determine the staging locations for apparatus and firefighters, upwind and uphill. Consider the use of time, distance, and shielding for protection of firefighters at the scene.

Fire departments should provide training in search-and-rescue bomb blast procedures. Use a limited collapse search-and-rescue operation and defensive firefighting operations, establishing hazardous material procedures and withdrawing to safety as needed. Fires and collapse are the leftovers of an explosion. First responders will be required to perform multiple simultaneous operations. After an explosion, firefighters will be required to provide medical assistance to injured people, protect exposures from fire, conduct collapse search-and-rescue operations to free victims trapped in the collapse rubble, and firefighting.

Fire departments should provide training on how to carry out evacuation procedures in nearby buildings during suspected bomb incidents.

Fire departments should train in bomb-seeking techniques until the Department of Homeland Security provides a more realistic rapid response by bomb-seeking experts to local communities. The National Guard, the U.S. army, and the FBI will not arrive in time.

Fire departments should lobby community leaders for Homeland Security training funding.

Until funding for training is forthcoming, read guidelines for bomb searching from the book *Emergency Response to Terrorism*, taught at the National Fire Academy.

Fire departments should review and update the following standard operating procedures for operating at terrorist IED incidents:

- ***Situation 1: Fire caused by a terrorist's IED.*** When firefighters at the scene of an explosion, collapse, and fire discover that the incident was caused by a terrorist IED, they should notify the police department, evacuate injured people, and protect the exposed building against fire from a safe distance.
- ***Situation 2: Discovering a terrorist IED after a fire.*** When firefighters discover an unexploded terrorist's IED after a fire has been extinguished, they must not disturb the device. Firefighters should evacuate people, withdraw a safe distance from the potential explosion area, and notify the police. Firefighters located at a safe area should prepare to protect exposed buildings from a fire; if an explosion occurs, firefighters may have to conduct a collapse search-and-rescue operation, then prepare for a hazardous material operation if the explosion is from a dirty bomb.
- ***Situation 3: Search and evacuation of a suspected IED area.*** When called to a terrorist's bomb incident by the police department, firefighters must report to the police officer in charge and assist as requested. If the police officer in charge requests that firefighters search for the bomb or evacuate a building suspected to have a bomb placement and the incident commander from the fire department decides to comply with the request first, additional reinforcements should be called for. These backup firefighters prepare for an explosion. After the explosion, firefighters may have to rescue trapped police officers and firefighters. A collapse search-and-rescue operation may be required. At the same time, a simultaneous HAZMAT operation may also have to be started.

20 HOSE PLACEMENT

There are five hose stream attack strategies commonly used at structural fires:

1. A frontal hose line attack is made by the first hose team of firefighters. This is the most common hose placement strategy used by the fire service. The frontal attack is successful at 95% of fires. When this strategy fails, the following hose placement strategies are considered.

2. A flanking hose line attack is a hose line advance toward a fire by the second or third hose team. This hose team uses an alternative approach, advancing on a fire from a right angle while firefighters of a first attack hose teams take cover.

3. An interior defensive hose team attack is used when firefighters must maintain control of a stairway and operate a hose stream from a stairway into an occupancy doorway. The hose team does not advance toward the seat of the fire owing to its size. This strategy is often used when fire is above the reach of the highest ladder and cannot be extinguished by an outside master stream; this is appropriate when there is a life hazard in the building above the fire and an evacuation is necessary. This strategy is used when fire is confined to one floor of fire, where the stability of the structure is sound. The intent is to eventually advance on the fire once the furnishings fueling the fire on the burning floor are consumed.

4. An exterior defensive aerial and/or deck pipe master stream attack is used when the above three strategies are considered ineffective or too dangerous and all occupants have been evacuated from the building. All interior forces are withdrawn to safety. This can be a temporary strategy, with firefighters returning inside the building with hose lines, or a final strategy, such as a surround-and-drown operation.

5. A nonattack strategy is used when people trapped in a stairway above the fire must escape down a stairway to get below a serious fire or when people are already evacuating a burning building on arrival of the first responders. The door to the burning office floor or apartment is not opened nor are the flames attacked with a hose stream, because these actions would endanger occupants descending the stairs. If the

door to the burning area is opened, it will spread smoke and fire up the stairway and stop the people from descending. This nonattack strategy can be applied for a short duration, as in a narrow tenement hallway, until several people are removed below the fire, or for a long duration, as in a high-rise office fire beyond control of an attack hose team.

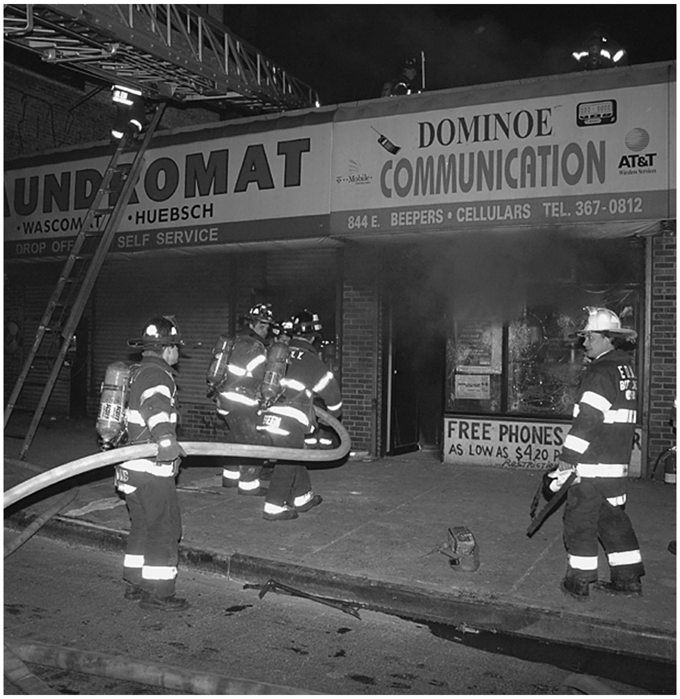


Fig. 20–1. Most fires are extinguished by the advance of the first attack hose team to the fire origin.

Frontal Attack

A direct, head-on frontal attack is the first, most often used, and most successful attack strategy at a fire. Firefighters drag a hose line straight into the path of a fire (fig. 20–1). They come face to face with the fire and extinguish it. For a room-and-content fire in a house or apartment, the first attack hose line is stretched by firefighters through a front, rear, or side doorway. The hose stream nozzle is positioned and used to drive heat, flame, and smoke from inside to outside through a vented window or other doorway or through an opening created by a firefighter assigned as an "outside vent firefighter." Ninety-five percent of fires in America are extinguished with this strategy.

When this frontal attack is properly positioned, this single action saves lives, prevents fire extension, extinguishes the fire, and reduces property damage. If the first attack hose team is successful, every other firefighting tactic will go smoothly. The searches will proceed quickly, firefighters will get into position, and venting will be effective; sufficient personnel will be available for laddering, and examination for fire spread will be performed safely above the fire. Rescues of trapped victims will proceed with less danger to firefighters.

However if the first attack fails, other hose lines will have to be stretched. The first hose attack team's hose line already stretched will confine itself to the task of protecting life. The other hose lines will have to be positioned at different locations where flames are spreading to confine and extinguish the blaze.

The priorities of hose line positioning are as follows, in the order given:

- To protect life (place the hose line between the flames and the people trapped in the building)
- To prevent the fire from spreading to the upper floors or to nearby buildings

Flanking Attack

A flanking attack is the second-most-often-used strategy at a structure fire. This strategy is used as an alternative when the frontal attack stalls and there is no serious exposure. During a flanking attack, a second- or third-arriving hose team (sometimes the second hose line has been used to back up the first line) advances toward a fire from a side exposure. A flanking attack becomes an option when the initial attack hose team is bogged down and cannot advance on the fire. It also is an option when fire attack stalls and a fire officer notifies the incident commander of a second approach to the fire that is relatively free of smoke and heat. If the initial hose team cannot extinguish the fire, a flanking approach should be tried. This flanking attack should only be undertaken by order of the incident commander. Freelance flanking should not be allowed.

A flanking attack is often used when air movements from an open window cause flames and heat to blow directly into the path of firefighters advancing the first hose line, stopping their forward movement. Another hose line can sometimes be stretched from a flank via a window, by way of a ladder or fire escape, or from another stairway. A fire can be effectively flank attacked from a right angle. Caution must be used to prevent hose lines from advancing from opposite directions; if this is done, firefighters from one or both hose teams can be scalded or burned by hot water from opposing hose streams.

Good radio communications and coordination are required by the incident commander when using a flanking attack. Sometimes when a flanking-attack strategy is used, one of the hose teams must retreat and closes a door, allowing the other hose team to advance. The incident commander and company officers of both hose teams must communicate with portable radios and coordinate action so that opposing hose streams will not injure firefighters.

After one, two, or three hose lines have been stretched into a burning building and firefighters are advancing them toward the fire, sometimes an incident commandeer sees no immediate need for another hose line. This is the time to have firefighters stretch a hose line to the front of the building and stand fast until there is another call for a line. When you order a fire company to stretch a hose line to the front of the burning building and stand fast, you are being proactive with your hose line placement. If there is a sudden need for a hose line to cut off spreading fire in a building, the firefighters standing fast with the line nearby can quickly take it inside the building. The advantage of stretching a hose to the front of the building and standing by is that the most time-consuming part of the hose stretch is completed. The firefighters must find a nearby pumper, select the proper nozzle and hose size, and stretch the hose to the front of the building with excess hose folded nearby. If the hose line is not needed, however, you can order the fire company to take it up.

Interior Defensive Attack

When frontal- and flanking-attack strategies fail, a third option, an interior defensive strategy, may be used (fig. 20–2). This can be accomplished in a fire-resistive building that will not collapse during the defensive attack. This strategy is sometimes called a controlled-burn operation. Several hose streams operate from several stair

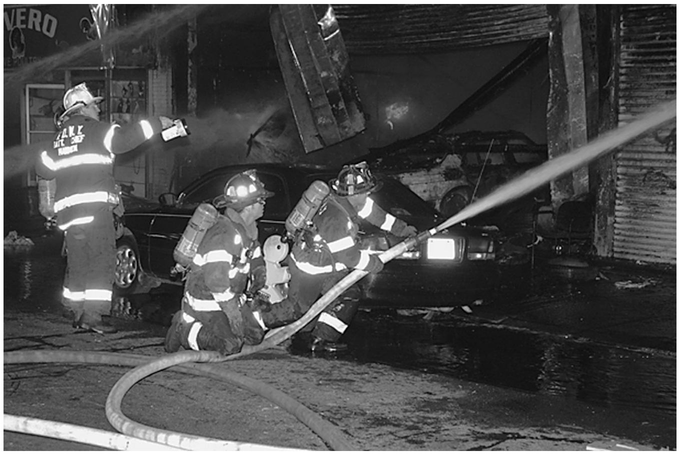


Fig. 20–2. A defensive hose line strategy is used when the initial advance and the flanking attack on the fire are unsuccessful.

enclosures while the entire contents of a floor are consumed by flame. The fire department controls the stairways with hose streams while people escape from the upper floors.

Some departments have portable deluge nozzles mounted on wheeled platforms that fit inside an elevator. These deluge nozzles can be used during an interior defensive attack. During a defensive strategy in a fire-resistive multistory building, the deluge nozzle is positioned in the stairway, taking the place of firefighters holding nozzles. One firefighter can monitor the deluge nozzle. Deluge nozzles have several advantages: a more powerful stream can knock down partitions and hit the fire, and the reach of the deluge nozzle is greater than that of handheld nozzles.

At an interior defensive firefighting operation, control of a portion of the building is maintained while the floors above are searched and occupants from above are allowed to escape down the stairs to safety below the fire. This strategy concedes the contents of one floor to the fire. Flame size and area of one floor of the building are beyond extinguishment by the fire department's handheld hose lines. This strategy should not be used when several floors are burning. When the fire spreads from floor to floor during an interior defensive attack, the incident commander should withdraw firefighters and start an exterior defensive attack strategy.

An incident commander should know that most floors in a fire-resistive building have fire spread ratings of one or two hours. The floor is overloaded and can collapse within that time. The lesson learned from the Philadelphia Meridian Plaza fire is that a fire can spread nine floors in a fire-resistive building, and high-rise fire-resistive buildings can be declared a collapse danger by a structural engineer. The lesson learned from the World Trade Center attack on 9/11 is that a high-rise fire-resistive building can totally collapse.

Exterior Defensive Attack

Over the past 10 years, every serious high-rise fire that spread to several floors above the original floor of origin had two common factors: the fire was beyond the reach of an outside aerial master stream, and the fire occurred after normal working hours. The One New York Plaza, First Interstate Bank, and Meridian Plaza fires are well-known examples of such fires. The buildings were classified fire-resistive construction and were unoccupied.

At a response to a high-rise fire, the drivers of the first and second ladder companies must position their apparatus for a possible rescue and/or outside aerial stream. There is always a chance that the frontal attack, the flanking attack, and even the interior defensive attack may fail and an outside master stream attack must be used. If the ladder is raised for an outside defensive attack, it should be positioned at a 75° angle from the horizontal.

Many fires on lower floors of high-rise buildings are located in outer rooms or offices that cannot be reached by interior attack hose teams owing to heat and flames over a large floor area. If the interior attack is unsuccessful, the incident commander may order an exterior aerial stream attack to extinguish a fire in an outer office. In this situation, the stream does not need deep penetration into the floor area. The fire may be confined in an outer office. The outside aerial stream may extinguish a fire near the outer perimeter office of a high-rise building after all interior firefighters have been removed to safety.

An aerial master stream can also be used to stop flames from spreading by autoexposure, from window to window (fig. 20–3). When the stream is directed at the spandrel wall of a high-rise building, flames lapping out a window from autoexposure can be stopped or slowed. A properly placed 100-foot aerial ladder can reach the 15th floor of a high-rise building and extinguish fire in an outer office room or possibly prevent fire spread from window to window.

Nonattack

A non-attack strategy where rescue and evacuation of people from above the serious fire may take precedence over all of the hose line positioning strategies already described. For example, if people are at an intermediate landing and descending a stairway and flames are threatening to blow out from a burning apartment or office occupancy while a hose company is about to open a door and attack the blaze, the incident commander should order a temporary nonattack strategy. Until all persons have safely been taken down the stairs, the door to the fire apartment should not be opened. After it is confirmed that all persons have descended the stairs, then the fire is attacked.

A nonattack strategy may be used by firefighters at a stairway in a high-rise building when there is a serious fire on the occupancy side of a stair door and

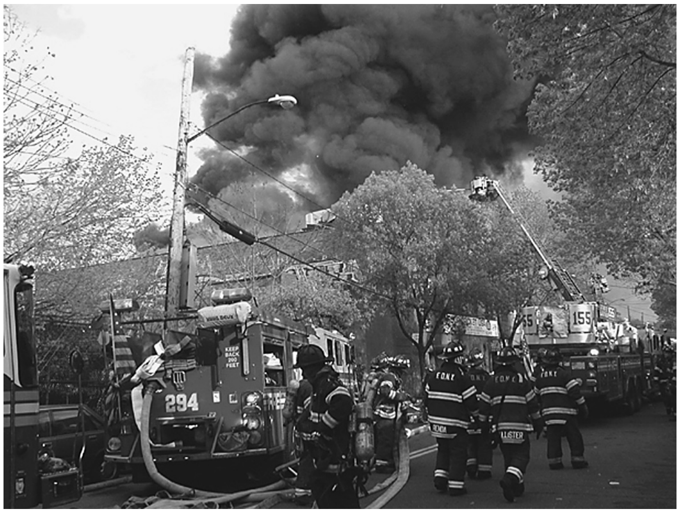


Fig. 20–3. These aerial master streams stopped fire spread by autoexposure.

people coming down the stairs would be burned if the door to the fire apartment was opened. The strategy is to delay the hose line attack until people in the stairs are brought down below the fire or, alternatively, to attack the fire from another stairway. The command post should be notified of these conditions and the decision to use a nonattack strategy.

21 STOPPING FIRE SPREAD

An incident commander must have a firefighting strategy to extinguish visible flames and invisible flames. Invisible flames are those concealed behind walls, ceilings, and floors. Most flames at a structure fire are not visible from the command post.

Once a fire has been extinguished, the incident commander does not immediately declare the fire under control. Over the years, a veteran incident commander realizes that fire may spread throughout the interior voids, shafts, and concealed spaces of a burning building. The progress report after all visible fire is knocked down might state, "The main body of fire has been extinguished. We are now opening up and checking concealed spaces for fire spread. The fire is still doubtful." This radio report means that the main visible fire has been quenched, but small pockets of fire not visible from the command post still exist. The entire blaze may not be under control. Every incident commander knows that after the fire is knocked down, there could be hidden fire spreading throughout the structure. Sometimes, the main body of flame is extinguished only to reveal a fast-traveling fire spreading throughout concealed spaces; consequently, a greater alarm must be transmitted.

Concealed Spaces

As soon as possible after a content fire, such as a stuffed-chair or mattress fire, is extinguished by the hose line, check to see whether flames have penetrated the ceiling. If a thermal-imaging camera is available, it will be useful in detecting concealed fire spread, behind a wall, floor, or ceiling.

Firefighters should open up the ceiling directly above the fire with pike poles (fig. 21–1). Open up the ceiling spaces until you see uncharred wood. Next, open up the ceiling around any pipe riser of a radiator system. Flames may have entered the small space around the pipe riser where it penetrates the ceiling.

If the fire room has a ceiling electric light fixture, the light may have to be removed, and the ceiling may have to be opened around the electric box. Electric power should be shut off to prevent electric shock to firefighters. After the ceiling light fixture has been opened and checked, the frames around the windows that were opened to vent the room fire should be

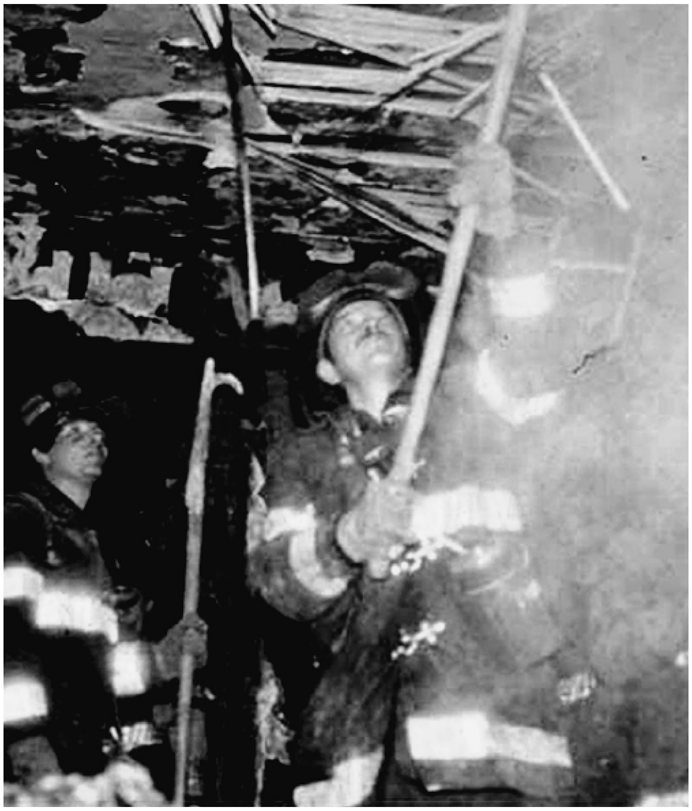


Fig. 21–1. After a content fire has been extinguished, open the ceiling above and check for fire spread in the concealed space.

examined. Flames and heat flowing out the window vent opening may have entered the concealed space around the windows. Firefighters with a pry tool can remove the window frames. This will expose the concealed spaces around the burned and blistered windows and will allow an examination for fire extension.

If the main fire was near a wall and there is a visible scorch mark on the surface, the walls near the fire origin must be felt. If the walls are too hot to touch or if you suspect that conduction heat penetrated a nearby plaster wall, open up several bays between the wall studs. If there is an electric socket in the wall, check around this potential area of fire spread. If uncharred wood is discovered in a concealed space, this indicates that fire did not extend there. However, if sparks, smoke, or heavy charring is seen, proceed as follows in an attempt to cut off fire extension.

If fire is in a wall, open up the ceiling above it. A hose line should be nearby when opening up to prevent fire spread. If fire is discovered in the ceiling, get another hose line and firefighters to the floor above, and open up the baseboard and partition wall. If fire has already passed the floor above, order a hose line to the top floor, and check the roof space and the attic, for fire may already be at this location. Large concealed spaces and poke-through vertical channels are often found in renovated buildings. If the fire was caused by arson and a flammable liquid was spilled on the floor as a fire starter, check for fire extension below the wood floor. Pry open several wood floor strips and/or pull the ceiling below to check for flammable liquids and embers.

Preventing Fire Spread to Windows of Nearby Buildings

If flame enters the window of an exposed building and it appears flame will spread to the area, firefighters should notify the incident commander of the potential fire spread to the exposure and request a hose line. The incident commander should order the fire company to close any outside metal shutters, shut the windows, and remove nearby combustible curtains or furnishings. If the building has a standpipe, the company should be ordered to stretch a hose line and extinguish any small fire entering the window. Determine if there are sprinklers. If so, the incident commander should order firefighters to supply the system. Most fires spreads to adjoining buildings by heat convection. Flame is a gas that transfers heat to adjoining buildings or from a window below to a window above, which is also called autoexposure.

Preventing Fire Spread in a Downwind Roof Space

When ordering a hose line to an adjoining store to cut off horizontal fire extension in a common roof space, you should also order firefighters to pull the ceilings to check for fire spread across the ceiling. Order firefighters to open up the ceiling near the partition that separates the fire occupancy from the adjoining exposed occupancy. The incident commander should request a report of any smoke or flames coming through the dividing partition or in the roof space. If the entire ceiling is opened and there is no indication of fire spread, check the roof. Flames could be spreading along the roof decking above. If there is no fire spread, above or below, the incident commander can concentrate on another avenue of possible fire spread. This report will greatly help the strategy. However, to be safe, monitor the area periodically. Fire conditions do change.

Shaft Fires

There are shafts designed in some multistory row dwellings that are intended to bring sunlight into rooms of the apartments. These shafts have windows built into the walls that allow rapid vertical fire spread from floor to floor.

Also, when fire enters the shaft, it may spread vertically, sometimes spreading into the common roof space at the top of the shaft through the eaves and the wood framework around the top opening of the shaft (fig. 21–2). Fire must not be allowed to enter the shaft, or if fire already is in the shaft, it must be extinguished quickly. These 2 ft × 2 ft interior light shafts may be enclosed by four plasterboard or wood walls. Located in the interior of the building, they extend from the basement to the roof. In some cases, the shafts start at the first- or second-floor level and are called blind shafts; in economically depressed neighborhoods, garbage fills up the bottom of the shaft, and a smoldering cigarette may ignite a shaft fire. In other

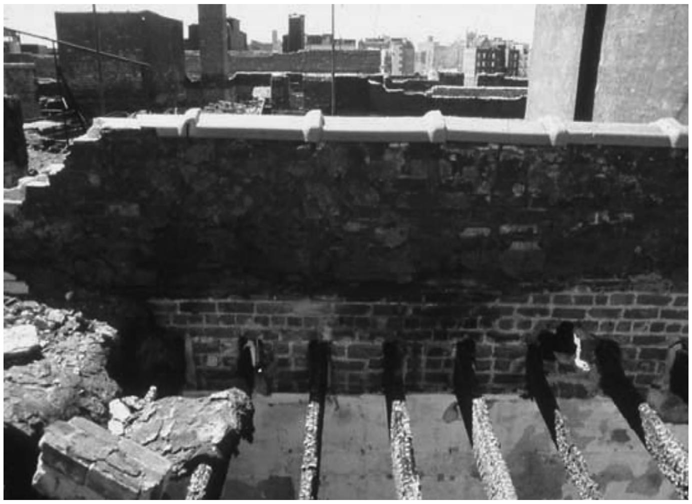


Fig. 21–2. When fire enters a shaft between buildings, you can have fire spread in two buildings.

buildings, the shaft has only three walls and creates a narrow alley between buildings that is open at the front or the rear of the structure. These (alley) shafts will extend from street level to the roof. Interior rooms have windows opening onto these shafts. These shafts are designed to bring sunlight and air movement into the interior rooms of the row houses, but they also spread fire from window to window and to the common roof space. Fire in an interior room may burn through a window opening onto the shaft, and then flames sweeping into the shaft may spread up the interior enclosure and out above the roof. Fire may also spread into any of the windows opening onto the shaft. Fire may also spread into the common roof space from a light shaft.

After the first line is stretched and it has been confirmed that fire has entered the shaft, a good strategy is to stretch the second line to the top floor to cut off fire, preventing spread into the top floor through the window opening onto the shaft. Next, order firefighters to pull the top floor ceiling with a pike pole, and with the hose line, stop the fire from spreading to the common roof space. Remember, the strategy is to prevent vertical fire spread and then prevent horizontal fire in a row house.

Fire Walls

During a defensive firefighting operation in a large one-story row of stores or a shopping mall, hose lines are sometimes positioned on a roof behind a parapet wall in an attempt to save a portion of a building. The party wall, which is a common wall between two buildings or two sections of a large building, acts as a fire barrier. A party wall may support roof beams of two adjoining buildings or spaces. The brick wall may be 8 in. thick and extend above the roof by 3 ft. Several hose lines positioned behind this brick wall may breed overconfidence. Party walls often have poke-through holes concealed below the roof and above the ceiling of the occupancy below. Always order firefighters to the store below to pull the ceilings. Examine the wall from below (fig. 21–3). Fire may already be spreading by way of poke-through holes in the brick party wall. There may be large openings in

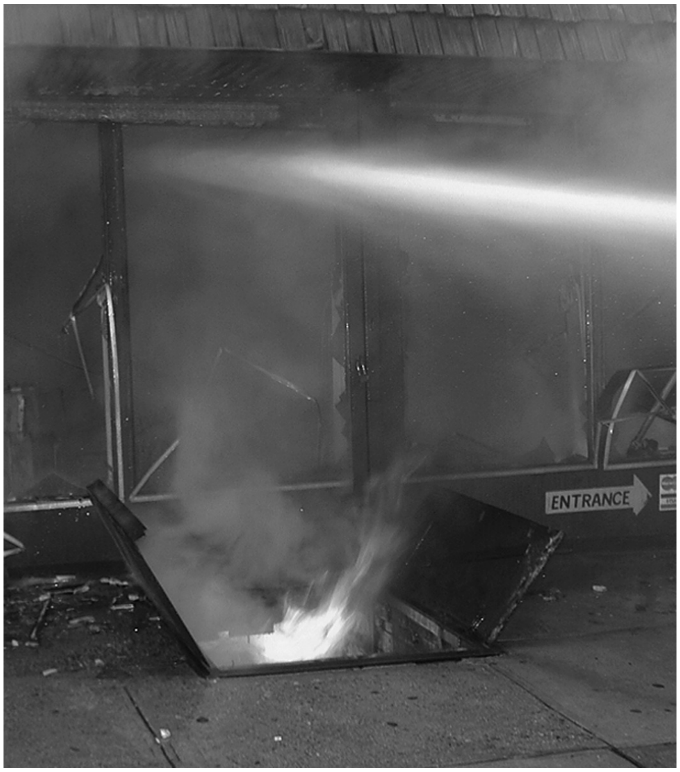


Fig. 21–3. The fire spread through small spaces in this party wall where roof beams were recessed in the wall.

a wall for air-conditioning ducts and pipes, or there may be spaces created by mortar cracks or missing bricks through which fire could spread.

What you see above the roof is not what you get below the roof. When workers renovate a building containing a row of stores, they may rebuild the party wall section above the roof where it is visible, but the important portion below the roof is often left unrepaired. When you position defensive hose lines on a roof behind a party wall, make sure you check the store below.

Cellar Fires

Because they are inaccessible, cellar fires are difficult to extinguish and to prevent from spreading. Some cellars may be considered concealed spaces. There are few doors or windows leading to a cellar; flames and heat rising through these few cellar openings make advancement of an attack hose line down to the seat of the fire impossible. If the attack team cannot extinguish the fire, the incident commander must realize that three things may happen:

- The fire may spread to adjoining cellars
- The first-floor beams may burn and weaken, causing the first floor to collapse into the burning cellar
- Flames may spread up concealed spaces to the upper floor, engulfing the entire building

To stop fire spread in a cellar that cannot be reached with an attack hose line advanced down the cellar entrance, the following actions can be taken:

- Have a company examine the adjoining cellars and the rear of the building for access to the fire and to prevent fire spread. Position hose lines at these points. Continually monitor for fire extension and carbon monoxide (CO) buildup.
- Cut a hole in the floor over the fire or as close as safety permits and pour high-expansion foam, or water from a cellar pipe if foam is not available. High-expansion foam will not fully extinguish the fire, but if it reaches the blaze, it will cool the cellar temperatures to a point where a hose line can advance down the cellar stairway and fully quench the fire. Openings in the cellar must be temporarily sealed for the foam to work.
- Prepare for a floor collapse. Withdraw firefighters from the first-floor area, and vent all windows and doors on the first floor (fig. 21–4).

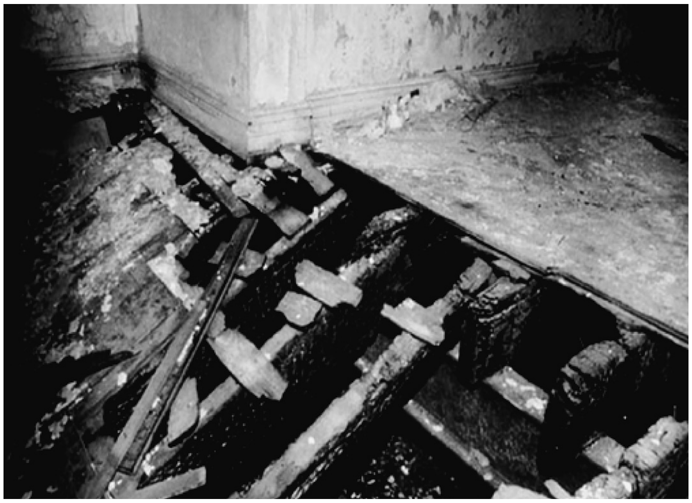


Fig. 21–4. Floor collapse is a danger during a cellar fire.

- If the high-expansion foam works, it may reduce smoke buildup and let firefighters search upper floors. Ladders positioned at windows and close supervision will be required to ensure that firefighters do not become lost in smoke on upper floors rising from the burning cellar.
- All upper floors should be checked for doors, windows, or shafts opening onto adjoining occupancies. If found, these horizontal openings should be closed to prevent fire spread to exposures; if such openings are found and closed, hose lines should then be positioned at these points or the areas continually monitored in the adjoining buildings. Flames could spread through small cracks around the doors and shutters.
- Set up an aerial master stream and prepare for a smoky, long-duration defensive firefighting operation involving the upper floors if the high-expansion foam fails to control the cellar fire. Flood the floor above the cellar fire.

Alley Fires between Buildings

At wood frame (type V construction) buildings, firefighters must often operate hose streams in narrow alleys between buildings to break up radiated heat waves spreading fire. When preventing fire spread from one structure to another, hand lines, portable deluge nozzles, and aerial streams are often positioned in yards, alleys, or streets to stop fire spread.

When it comes to preventing fire spread between buildings, the following guidelines are offered:

- If the building generating the flame and radiated heat is small and hose is available, direct the stream at the fire and extinguish the blaze.
- If the fire from the burning building is large and the hose stream is small and if after several seconds there is no effect on the fire, direct the stream at the side of the nearby exposed building.
- In all situations when a nearby building is threatened, order a hand line inside the exposed building just in case fire has spread to the interior.

Methods of Fire Spread

There are three methods of fire spread or heat transfer: convection, radiation, and conduction. They can occur at every fire. However, at structural fires, hose line placement to protect exposures is concerned mostly with convection.

Convection

Convection currents of heat are the most common type of fire spread. Flames lapping out a window, spreading up a stairway, or shooting through a roof are convection currents of heated gas. Flame is the gas of combustion that transfers the heat. Convection currents rise upward. As air is heated, it becomes lighter than the surrounding unheated air and rises. Flames usually rise upward in the atmosphere when there is no wind.

Radiation

The spread of fire to a nearby building by radiation occurs less frequently than convection fire spread. Radiation is defined as the transfer of heat through space. An incident commander should prepare for radiation fire spread at large fires, such as a lumberyard, heavy timber mill construction, and fully involved wood frame structures (fig. 21–5). When fire spread by radiated heat occurs, it spreads suddenly, in all directions. Radiation can spread fire across large distances. Radiated heat waves have spread fire across streets 90 feet wide.

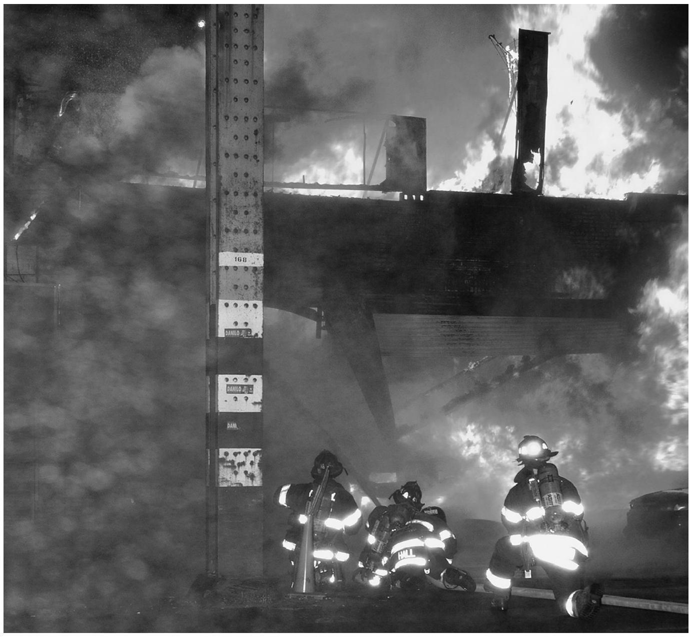


Fig. 21–5. Radiation fire spread is a problem during a large fire.

Conduction

The transfer of heat through a solid must be considered when conducting salvage and overhauling. Heat may conduct through the metal roof of a noncombustible (type II construction) building and ignite the tar or plastic insulation used in the roof covering. Also, when a windblown ember lands on the roof of a building and ignites the roof deck, the spread of fire through the roof deck is by conduction.

Tall Adjoining Buildings Exposed to Fire

If there is no wind and the flames and burning embers are rising straight upward, a taller building is more likely to catch fire than a building that is the same height or a building that is not as tall as the original fire building. Convection currents of heat and flames rise and may extend into windows of the taller building. Radiated heat may ignite wood windowsills in a brick building; the wood eaves or cornices of the taller building may also spontaneous ignite from heat radiation. Flying brands and embers from the lower building roof fire may blow into windows of the higher building.

When firefighters stretch a hose line into an exposed building adjacent to a fire that is several stories higher than the burning building, the purpose may be first to protect it from fire spread. Once the building is protected, the hose stream can be directed on the flaming shorter building from a good vantage point. When the purpose of the hose line is to protect the building from fire spread, there is a special way in which the hose should be stretched. Hose stretched into a three- or four-story building must be able to reach each floor and the roof.

When the hose is stretched by firefighters to a taller exposed building, it must protect the entire building. For example, to protect a four-story building in the path of a fire from an adjacent one-story building, stretch the uncharged hose to the top floor; then fold it back down to the second floor. The nozzle should be taken to the window closest to the fire on the second floor, facing the fire, where the greatest chance of fire entry exists. The uncharged excess hose is played out up the stairs to the fourth floor. This way, if flames enter on any floor or the roof, the repositioned hose could quickly reach it. The entire building could be protected by one hose line.

During the fire, firefighters must continually monitor all floors and the roof of an exposed building in the path of flames. Windows facing the fire should have outside shutters closed, all open windows should be closed, and curtains or combustibles near the closed windows should be removed.

22 OPPOSING HOSE LINES

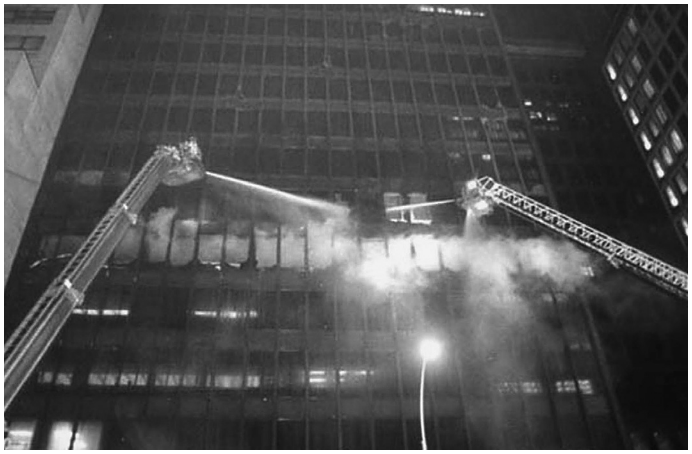


Fig. 22–1. Firefighters inside should be moved to safety before master streams are used from the outside.

At some fires, the initial attack hose line cannot advance on the fire, and another hose team is ordered to advance on the fire from an opposing direction. This is a complex firefighting operation that requires a plan to accomplish. If this opposing line strategy is not coordinated and controlled, it can injure firefighters and spread the fire. This is especially true when one hose line is advanced by firefighters inside a burning building and the other line is directed or advanced from outside the building through a flaming window.

The pressure and velocity of water from an outside hose stream directed through a flaming window will cause the fire and heat to blow back into the faces of advancing firefighters (fig. 22–1). As a result, steam or hot water may scald or seriously burn firefighters; their helmets and the face masks of breathing apparatus may be dislodged. A powerful hose stream striking a firefighter in the side of the head can puncture an eardrum. More seriously, fire driven back into the path of firefighters advancing an opposing hose line may cause them to drop the line and become disoriented and lost in a burning building.

The superheated air, steam, and hot water pushed ahead by a hose stream from an opposing hand line can cause injuries. A large-caliber master stream directed from an aerial platform or deck pipe into a flaming window where firefighters are advancing a smaller attack line is the most serious situation, but smaller-diameter hand lines operated in a window by firefighters can be just as dangerous.

Years ago, opposing hand lines were a common fire ground problem. Lacking portable radios with which to coordinate operations, firefighters often unknowingly directed opposing hand lines against each other for long periods. Each company thought the fire was preventing their advancement when actually the superheated gases each hose line was pushing against the other was preventing advancement and fire extinguishment. Today, no excuse can be made for the operation of opposing hand lines. Incident commanders, company officers, and some firefighters are equipped with portable radios, so opposing lines should not be a fire ground problem. In fact, at some fires, it is good strategy to position hose lines at opposite sides of the burning building (fig. 22–2). It is not, however, good strategy to have both of them directed at each other or to advance them into the building from opposite directions.

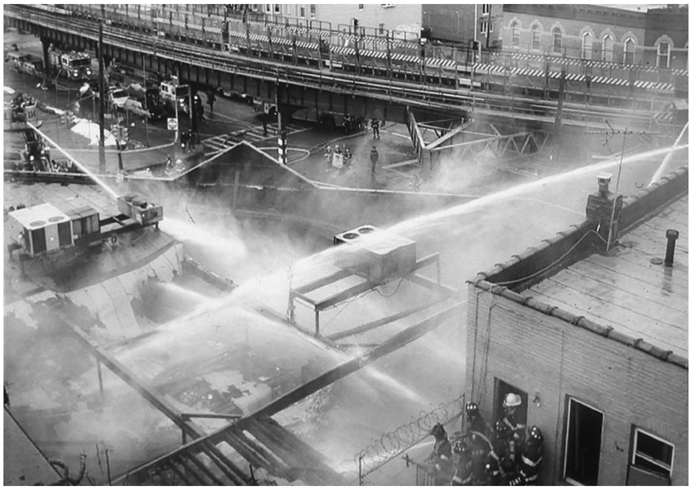


Fig. 22–2. Opposing hose streams can be used safely given good communications.

The first hose line often advances through the front entrance, and the second line backs up the first line or goes above in a multistory building. However, if there is a serious exposure problem, the second or third hose line may be sent around to the back of the building.

The hose line positioned at the rear of the building does not attempt to advance from an opposite direction to the first attack hose team. Instead, it may be used at the rear of the burning building to prevent fire from spreading to a nearby building, to stop flames from spreading up the surface wall of a wood-shingle frame dwelling, or to prevent flames from entering the attic space by burning through the cornice or eaves. This hose line may also stop autoexposure by being directed against the spandrel wall. However, this hose line is not directed into a flaming window when the first line is advancing from the opposite side and extinguishing the main body of fire; it is intended to prevent fire spread. It does not advance on the fire, unless directed by the incident commander. This may happen, but only in rare circumstances.

An example of such a rare circumstance would be when the first hose line is prevented from advancing on the fire from the front of the burning building. Then, the hose line positioned at the rear might be ordered by the incident commander to advance and extinguish the fire. This is not a common strategy; only in unusual conditions will this happen. It is not good practice for an incident commander to constantly vary the avenue of hose line attack to extinguish routine fires. However, this must be considered as a alternative strategy to be used when the wind blowing through a window prevents the advance of an attack hose line.

Everyday room-and-content house fires are fought the same way by fire departments. Strategies may vary from department to department, but within each fire department, they do not vary much at such fires. Fire departments often require several ladder company firefighters to operate simultaneously with the hose attack team. Firefighters in many fire departments take positions inside a burning building as a team with a standard operating procedure.

Firefighters have assignments to complete, and they must get to certain positions inside or around the building. Even though the first attack hose line is brought through the front door, other firefighters enter the burning building through side windows or rear doors, while still others go to the floor above the fire and to the roof. These firefighters at different locations search, vent, and force locks, and they expect the hose line attack to come from a certain direction. When the direction of the hose line attack is changed, they are put in jeopardy. Firefighters may become trapped or injured owing to the absence of the expected hose line attack or if the hose line attack comes from another unexpected direction.

Ninety-five percent of the structure fires in the United States are extinguished by one attack hose line. Most of the time, this attack hose line is advanced through the front door. However, at a small number of those fires, the firefighters cannot advance the first attack hose line. In some instances, a second hose line backs up the first line. Together, they attempt another advance on the fire. The second hose line may be of a larger diameter, discharging more water. If the two lines fail to move in on the blaze and extinguish it, then hose lines may be ordered to advance from the rear or from another direction.

Strategy Change

Changing the strategy of attack hose lines is very difficult. Advancing an initial attack hose line through several rooms of flame and heat to extinguish a fire is a brutal, punishing act. To accomplish this feat, firefighters must drag several hundred pounds of hose, spewing a ton of water at 50 pounds of pressure out of a nozzle. They must crawl ahead blindly, over a hot bed of ashes, through several rooms with scalding steam as chunks of red-hot plaster and boiling hot water rain down on them. To ask these firefighters to stop everything, back out of the fire area, and close the door while another company approaches the fire from the opposite direction is not easily accepted. However, when it becomes obvious to the inside sector (operations officer) that the initial attack hose line is not going to be successful and another approach will quickly extinguish the fire, this strategy change must be ordered. To accomplish this, several steps must be taken.

Implementing a change in strategy

First, using portable radio communications, the interior sector commander notifies the incident commander of the inability of first attack team to advance. Next, the incident commander orders the change in firefighting strategy to advancement of an opposing line. Then, by portable radio, a second hose attack team is ordered into position at the opposite point of attack.

Once the alternative hose team attack officer gives a “ready” signal, the interior sector commander orders the initial attack hose team and all firefighters inside the fire area to back out of the fire, into the hallway, with the initial attack hose line.

(This will take a strong interior sector commander and a forceful order. The firefighters will clearly not want to retreat, but a well-trained, disciplined firefighting company with an effective officer in charge will comply.) Next, close the front door to prevent the fire from spreading back into the hallway. Only when all of this has been accomplished is the order given over the portable radio to advance the hose line from the opposite direction to extinguish the fire.

Reasons for a change in strategy

Heat is the major reason why firefighters are unable to advance a hose line. Superheated gases and steam in a dwelling or store sometimes bank down to floor level and engulf firefighters pushing a hose line forward. In this instance, they may be forced to back out of the fire area when intense heat descends from the ceiling. Venting windows, doors, and skylights just before the hose line is advanced can dissipate built-up superheated gases and steam in a fire area. Until the fire is vented, firefighters will be prevented from extinguishing the blaze using an inside attack.

Wind also can prevent the advance of the hose attack team. Even if the fire area is vented, a strong wind blowing through a fire area toward firefighters attempting to advance an attack hose line will drive heat and flames into their path. A hose stream operated from an entrance doorway cannot extinguish a fire burning several rooms back. Windblown fire gases mixing with air and turning to flames at the entrance doorway will be reached by the hose stream, but it will not reach the seat of the fire. To extinguish any fire with water, it must be discharged directly on the burning material, not on the convection currents. When wind blows 30 mph or more, a fire chief should anticipate problems in advancing an attack hose line. In this instance, venting windows opposite the hose line advance may not be as effective as venting side windows or skylights.

Tall stacks of storage material and stock also may prevent advancement. Room partitions and material piled up to a ceiling in a store will block a hose stream. Some mentally ill people, over many years, save miscellany such as papers and rags that obstructs firefighters' hose stream. It is impossible to advance an attack hose line to the seat of a fire in these structures. Water from a 30- or 40-foot hose stream will be prevented from hitting the fire. Firefighters are justifiably fearful of advancing too deeply into such a cluttered fire area.

If the piles of stored material collapse or if a flashover occurs, the chance of escape is small. Firefighters can easily become disoriented and lost in smoke-filled mazelike fire areas. Excess hose coiled up in several rooms, snaking in and out of the fire area, cannot be used to get back safely. Thus, firefighters cannot find their way to the outside even by following the hose line.

High-Rise Buildings

The most frequent reason to require a hose line to advance on the fire from the opposite direction of the initial hose line advance is wind (fig. 22–3). Wind blowing into the fire area will push flame and heat into the path of the firefighters advancing the first attack hose line. At fires in high-rise buildings, wind blowing through broken windows into the path of firefighters also prevents advancement of the initial attack hose line. Unfortunately,

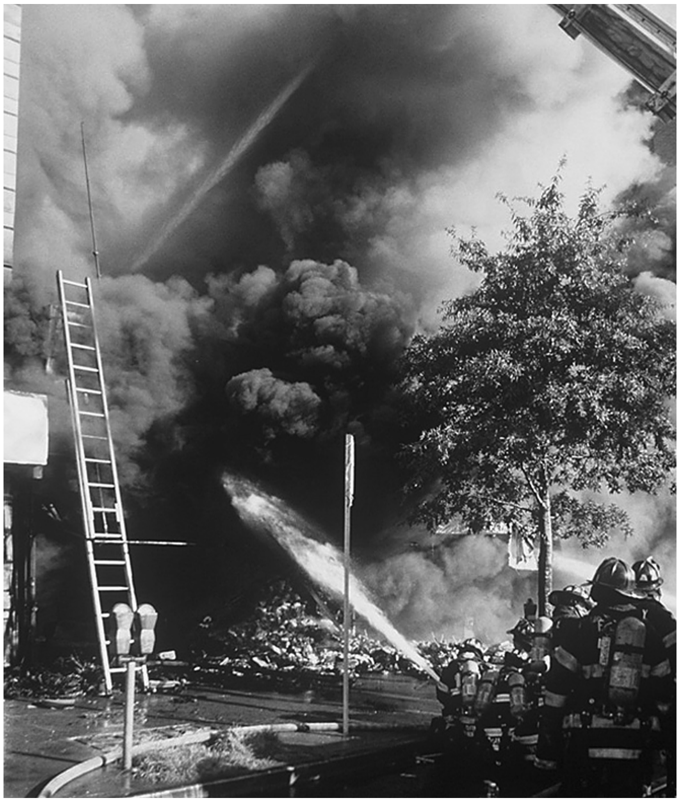


Fig. 22–3. Hose streams are directed from upwind.

when the fire is beyond the reach of the fire department ladder, on an upper floor of a high-rise without fire escapes, an incident commander cannot order a hose team attack from the opposite direction.

The usual strategy is to withdraw firefighters to the relative safety of the enclosed stairway and wait for the fire to burn itself out. This controlled burning can be considered by the incident commander only in a fire-resistive high-rise designed to confine a fire to one floor and only when the structure is not in danger of collapse. If the high-rise is not fire-resistive and fire spreads to the floor above or if the structure is deemed unstable, the occupants and firefighters must be withdrawn from the entire building and an outside firefighting strategy will be ordered.

Some fire departments are developing high-rise firefighting procedures to combat the effects of wind on an initial firefighting attack team. For example, a small asbestos curtain is lowered by rope from the floor above in front of a broken window to prevent wind from blowing on the advancing firefighters. Another procedure is to use a World War II vintage 10- or 12-foot Navy low-pressure fog applicator. It is raised from a window on the floor below, and the nozzle is directed up into the broken window on the fire floor through which the wind is blowing. This fog solution depends on the indirect extinguishment of the fire by wind and expanding steam. It is done after interior firefighters have been withdrawn and the interior door to the stair enclosure has been shut.

23 SMOKE VENTING

An incident commander must have a strategy for venting a fire. There are five venting strategies used at fires:

- Vent to facilitate advancement of a hose line
- Vent to saves lives on the top floor of a building
- Vent to prevent a smoke explosion
- Vent to limit fire extension inside a burning building
- Do not vent

To vent smoke and heat from a burning building, the incident commander may order firefighters to use fans; open doors, windows, skylights, scuttle covers, roof stair doors, and cellar sidewalk doors; and cut openings in a roof. Venting releases smoke and heat from a burning building and can greatly assist firefighting. Technically, a venting strategy is an attempt to control smoke movement. You control smoke movement sometimes by releasing it from the burning building, and sometimes by confining it to an enclosed area. If the decision is to vent, the incident commander orders fire companies to open strategically located doors, windows, skylights, and scuttle covers and make roof saw cuts to release smoke and heat from a burning building.

An incident commander may order fire companies not to vent at fires. This strategy can also save lives, assist a hose line advance, prevent or reduce effects of an explosion, and limit fire spread.

Advancing a Hose Line and Venting

For an attack hose line to advance and extinguish a fire, smoke and heat may have to be vented from the area. The removal of products of combustion improves visibility and reduces heat in a burning room. Venting removes heat and smoke from the fire area and allows firefighters to advance close to a fire and extinguish the flames with the hose stream (fig. 23–1).

When firefighters advance with a hose stream, smoke is pushed ahead of the hose team's advance. A straight stream moves some smoke and heat ahead, and a fog nozzle can push great volumes of smoke and heat forward. If firefighters do not vent, the smoke and heat will blow back at the firefighters and cause severe burns. Windows should always be vented in

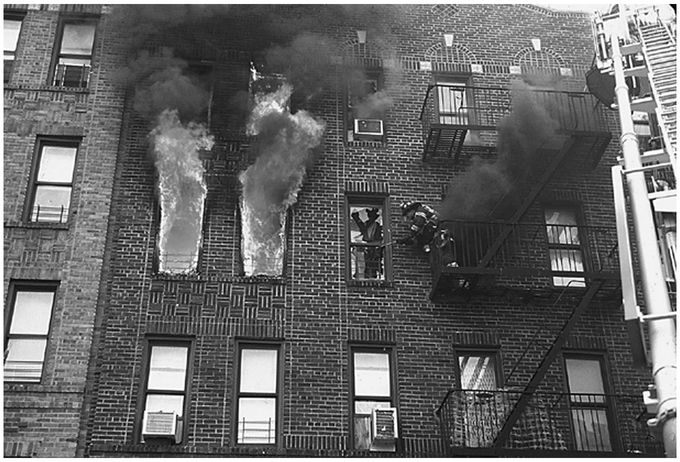


Fig. 23–1. A firefighter venting a window to assist advancement of an interior hose in an apartment next to the fire.

front of the hose line advance. Sometimes, the heat of a fire can also cause smoke to move.

In addition to venting, there are other causes of smoke movement during a fire. The incident commander should know them and take advantage of these smoke movement causes when possible. Wind blowing through a building can move smoke. The wind permeating the building can move smoke through several rooms or a throughout a common roof space. Wind blowing into a window can push heat and smoke into the path of advancing firefighters and can stop a hose attack team. Cross venting—opening windows at two ends of a building—can take advantage of this wind movement.

Another cause of smoke movement is pressure buildup in a burning room. The pulsating waves of flame, as a room fire grows, can move hot smoke out of a room into nearby areas. Smoke will be moved to adjoining rooms and spaces by the heat waves of the fire. Shutting the door to the fire room and venting windows at the perimeter of a burning building can relieve this buildup of smoke under pressure, coming from interior rooms.

Smoke is also moved by convection currents of heat. Flames spreading out a doorway or window are actually convection currents of heat moving flames and smoke with it. The heated convection currents can move the smoke upward through several floors. Shut windows on the floors above to stop smoke movement into floors above by these convection currents of heat and smoke (also called autoexposure).

Smoke is also moved throughout a building by HVAC systems. HVAC systems should be shut down to reduce the smoke movement.

The stack effect in a sealed high-rise building is another cause of smoke movement. The stack effect is caused by the difference in temperature and pressure inside and outside the sealed building. The strategy for reducing the movement of air by the stack effect is to not vent. By not venting, you keep the stack effect to a minimum. If you vent a high-rise building, you may increase the smoke movement due to the stack effect.

Strategies for Not Venting

Autoexposure—that is, when flames blowing out a window flow up to a window above—spreads fire and smoke. When this happens, the window above should not be vented, and if open, it should be closed by firefighters. The glass window may temporarily delay fire spread to the floor long enough to allow a hose line to be stretched. If the window above a fire is vented, this could allow flames from below to enter and spread to the floor above.

A central air (HVAC) system can also forcefully move smoke up and down several floors of a building. If the HVAC system remains on during a fire, the smoke is moved through the system's air ducts by pressurized air. This mechanical venting must be stopped. The HVAC system must be shut down when arriving at a fire.

Finally, another reason not to vent is the stack effect. This is a natural movement of air in a sealed high-rise building. The stack effect is caused by the difference in pressure and temperature inside and outside a tightly sealed building. This natural air movement, called stack effect, can move air 10–20 floors up stairs, elevator shafts, and utility closets. During a fire, it will also move smoke the same distance. Because of the stack effect, the strategy when fighting a fire in a high-rise office building with an HVAC system is not to vent windows.

High-rise residential buildings are built differently than high-rise office buildings. The windows of high-rise residential buildings can be vented. The stack effect in a high-rise residential building is not as great as in a high-rise office building because the buildings are not sealed. The apartments have unit air-conditioners, rather than a central air system with ducts penetrating floors and walls. Also, windows are openable, and apartments are limited in floor area. The many apartment and stair doors and partitions limit the stack effect.

During a fire in a low-rise building, it is not always a good strategy to vent. There are times when the incident commander's decision not to vent actually helps the advancement of the hose line and searching firefighters. For example, the incident commander may decide not to vent a burning building when the hose line team is not ready to advance, and premature venting of a window or door may spread fire or increase its size. Also, the incident commander may decide not to vent a smoke- and heat-filled room when there is a firefighter inside searching for victims and the venting could cause a flashover and entrapment. Another example when venting is not recommended is when the smoke- and heat-filled room appears to be about to flashover or explode and, again, there is no hose line ready. The incident commander may decide not to vent a burning building when people are descending a ladder or a fire escape and venting a window would block their passage with flames. Furthermore, an incident commander may decide not to vent a roof if the flames coming from the roof vent would spread to an exposure.

The incident commander may decide not to vent windows if the wind blowing through the vented windows would stop the advance of the hose team. In this instance, the strategy may be to close or cover a window that has already been vented. The incident commander may decide not to vent a roof skylight or scuttle cover when the roof beams are lightweight wood truss construction, steel bar joists, or a timber truss and there is a danger of collapse and injury to a firefighter on the roof. The incident commander may decide not to order venting of the windows of a high-rise building when the stack effect could cause the smoke to move in a harmful and/or unpredictable manner throughout the building. The incident commander may decide not to vent when the falling glass would injure people in the street below. The incident commander may decide not to vent a window when autoexposure would spread fire to the floor above.

Despite all these examples in which nonventing is the strategy, at most fires, the best strategy is to vent heat and smoke from a burning building. Venting saves lives. An incident commander must consider both strategies.

Venting to Save Lives

In a multistory residence that has one stairway serving the entire building, venting the roof skylight, scuttle cover, or bulkhead door at the highest point over an interior stairway during a fire saves lives by removing toxic gases and smoke from the top floor. If a fire occurs on the lower floor of a multistory residence, firefighters usually attack it from the interior stairway.

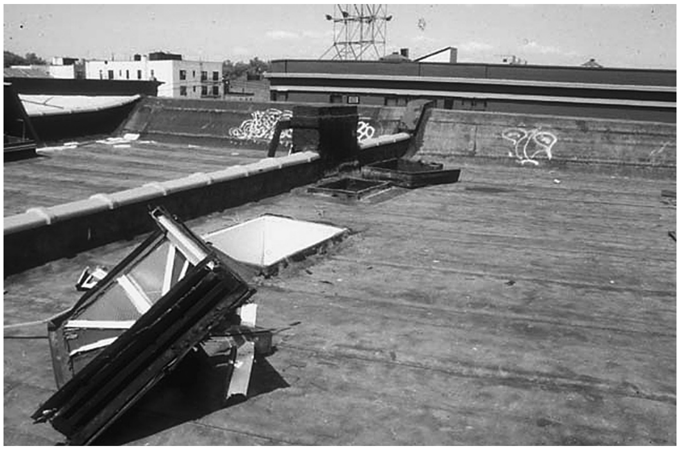


Fig. 23–2. Venting the roof scuttle saves the lives of occupants on the top floor.

As firefighters direct and advance the hose line into the apartment, smoke and heated gases flow out of the doorway over their heads. These deadly products of combustion rise up the interior stairway and accumulate on the top floor, then bank down and mushroom out, seeping into top-floor apartments and endangering occupants. Years ago, before the value of firefighting ventilation was understood or acknowledged, fire on the lower floors of multistory residences was extinguished and confined there; however, fire victims were later discovered dead on the top floor. Smoke from the fire several floors below would flow up the interior stairs, accumulate on the top floor, billow out horizontally, and asphyxiate sleeping or trapped people. Venting over the top of the interior stairway, by removing the roof skylight, scuttle cover, or opening a roof bulkhead door, prevents a deadly top-floor buildup of smoke from a fire on a lower floor and saves lives (fig. 23–2). When there is one stairway in the building, this venting must be carried out immediately, without hesitation, when fighting a serious fire in a multistory building. Without this stair venting, firefighters operating hose lines from the interior stairway would be forced off the floor by heat and smoke banking down from the top floor.

However, when there are two stairways in a burning multistory building and the strategy is to use one stairway for fire attack and the other for occupant evacuation, the following actions must be considered: The designated attack stairway can also be used to vent smoke and heat from a lower-floor fire. The other stairway should be kept clear of smoke, so that people can be instructed to use this stairway to leave the burning building (fig. 23–3). To vent a stairway, firefighters must get to the roof. In a low-rise building (under 75 feet high), this can sometimes be accomplished from an adjoining building or by climbing a ladder or using the stairway free of smoke for occupant evacuation during a fire. No door to the

Fig. 23–3. When the building has two stairways, designate one for evacuation and one for fire attack.

fire occupancy should be opened from the designated evacuation stairway.

Venting a fire area is often necessary for hose stream application. Hose streams directed by firefighters have an effective reach of 30–50 feet. Often, partition walls and building contents obstruct the reach of a hose stream. Effective extinguishment from an interior attack hose team requires firefighters to closely approach a fire to direct water on the point of origin. Firefighters with SCBA are no longer prevented from closely approaching a fire owing to toxic or irritating gases; however, poor visibility caused by dense smoke and a highly heated atmosphere still keep firefighters away from the fire source, preventing a quick fire extinguishment. Venting windows and doors in a fire area on the opposite side, away from where the hose stream is being directed, lets firefighters approach a fire quickly and extinguish it safely. At a one-story building, venting can be accomplished at the front or rear from the ground level by opening doors and windows.

At a multistory building, for firefighters to reach the windows, they must climb a ground ladder, aerial ladder, or fire escape. In some instances, venting should be timed with the advance of the hose attack team; if venting is carried out before the hose team is ready, the fire may spread or firefighters inside a superheated room conducting a search may be burned by a flashover. The strategy of venting for a hose line creates exhaust openings in the room or fire area away from the advancing hose team. Steam and superheated smoke and air are pushed ahead and out of the room by the advancing hose stream. This will assist the hose attack team to advance on the fire.

Venting to Prevent Explosions

Venting can prevent backdraft or smoke explosions and can reduce the deadly blast effects of other types of explosions (fig. 23–4). Smoke explosions, natural or bottle gas explosions, and BLEVEs (boiling liquid expanding vapor explosions) occur in strip mall and shopping center fires. Explosions sometimes blow out front plate glass windows into the faces of advancing firefighters.

The objective of explosion venting as a firefighting strategy is to release explosive gases before they build up and explode and to release the blast in a safe direction if the explosion occurs. Early removal of a glass skylight or scuttle cover by a firefighter on the roof during a serious fire in a strip mall

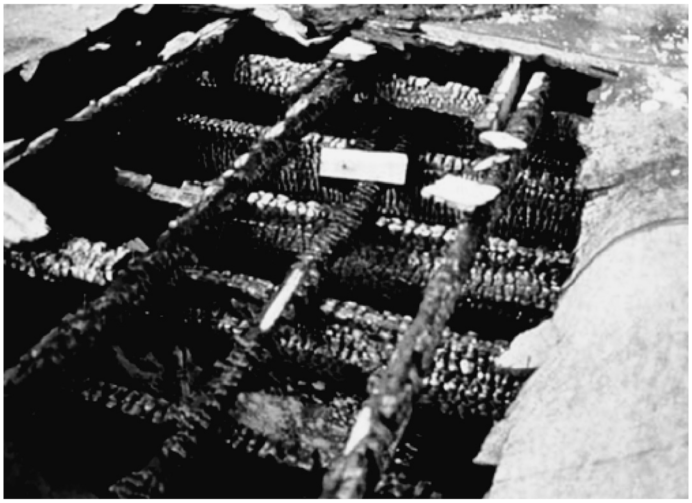


Fig. 23–4. The roof of a strip mall store should be vented immediately to relieve smoke and heat and reduce effects of an explosion.

or shopping center will accomplish this. If the first opening in a burning store is the roof skylight or scuttle and an explosion occurs, some of the expanding gases and the blast will be diverted harmlessly up out of the roof opening and not toward the front entrance where firefighters are advancing to extinguish the store fire.

Ventilation at the rear of a store should also be performed; however, it is sometimes ineffective when the fire is at the front of the store. Partition walls and storage of stock often separate the front and rear of the store. In all instances, the front store display windows should be removed to reduce levels of smoke inside the store. Before a hose line attack starts, firefighters should stand safely to one or both sides of the large front windows with charged hose lines. After the front windows are vented and the heated gases flow out, there may be an explosion or fire ignition. As soon as possible after venting the front windows, hose streams should be directed into the store from a flanking position. After the initial smoke and heat release from the store and if fire conditions permit, firefighters then advance into the store and extinguish the blaze. Firefighters advancing into a store where neither the roof nor the rear can be vented must realize that they are in effect entering the barrel of a loaded shotgun. If there is an explosion in the store, they will receive the full effect of the blast. Venting at a strip mall allows the advance of a hose line, prevents an explosion, saves lives of firefighters, and prevents fire from extending to adjoining stores through a common roof space.

Venting to Control Fire Spread

The most serious and most frequent structural fire spread problem is the common roof space. This area below the roof deck and above the ceiling may extend horizontally over the entire top floor of a building or over several stores or an entire block of row houses.

Fire can spread to the common roof space from a concealed space. Fire can spread to the common roof space by burning through a top-floor ceiling, and in some instances, fire starts in the common roof space, as when an arsonist cuts a hole in the roof and pours flammable liquid into the roof space. Once the flammable liquid is ignited, it will spread rapidly throughout the entire common roof space. Fire and smoke will spread horizontally to the outermost limits in the roof space.

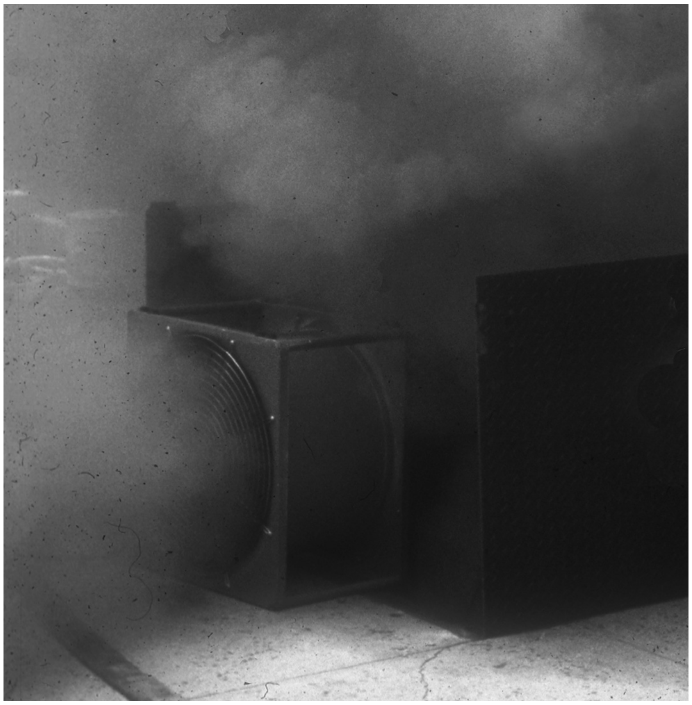


Fig. 23–5. Cutting a hole in a roof can prevent fire spread in a common roof space.

To control fire and smoke spread inside a concealed roof space, a vent opening must be cut in the roof directly over the main area of fire or as close to it as safety permits (fig. 23–5). The cut pieces of roof are pulled up, and the ceiling below is pushed down with hooks. When this action is taken by firefighters, a thermal updraft will be created, pulling flames and smoke out of the store and the concealed roof space. The venting strategy is to reverse the mushrooming fire in the roof space and have it rise, exiting through a roof vent cut. This venting will allow firefighters to enter the store, open up the remaining ceiling with pike poles, and extinguish the fire with hose streams.

Positive-Pressure Venting

All of these smoke-venting strategies can be enhanced by positive-pressure ventilation. Fans placed at the bottom of stairs or on the upwind side of a smoke-filled room can speed up smoke venting. However, with the use of positive-pressure venting, the incident commander must realize that there is the potential for smoke and fire to spread to adjoining spaces. If firefighters are entering a building from the opposite direction, the use of a fan to assist smoke venting may push fire and heat toward them and cause disorientation in the smoke and serious injury. Positive-pressure venting is most effective at one-story residential buildings where the entire search team and fire-attacking personnel advance from the same side of the building.

At a multistory building or in buildings built in rows or directly behind one another, smoke and fire may be spread by the use of positive-pressure smoke venting. Using fans to vent smoke is very effective and highly recommended in any type of structure for the removal of residual smoke after a fire has been extinguished.

24 SEARCHING AT FIRES

Nothing indicates a poor firefighting operation more clearly than firefighters leaving the scene of a fire and having a victim found by people at the scene several days later. To avoid this public relations disaster, there must be a search strategy. There must be a systematic, organized, coordinated primary and secondary searches conducted at every fire.

The search for fire victims should start immediately when units arrive on the scene (fig. 24–1). This can be accomplished if there are enough responding firefighters on the initial alarm available to perform the hose attack and search simultaneously. Searching for victims and fire suppression will take place together. However, in a rural volunteer community, if there are only enough firefighters available to extinguish a fire, the search for victims may have to be delayed until the fire is extinguished. Fire extinguishment by the fire attack hose team is the single most important lifesaving action taken at a fire. Firefighters stretching hose may conduct incidental primary searches as they pull hose into position.

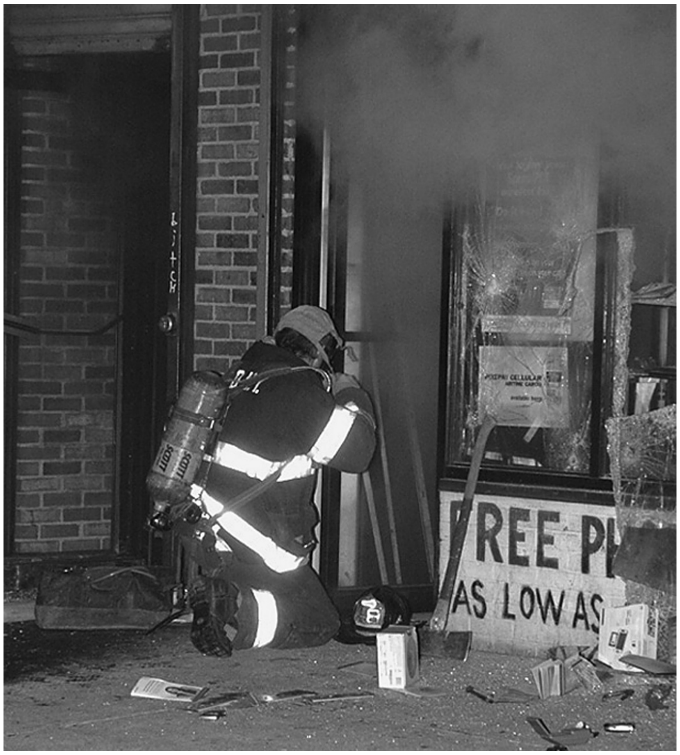


Fig. 24–1. Conduct a primary search on arrival at the scene.

A more thorough secondary fire victim search should start immediately after the blaze is extinguished. At this time, the danger to searching firefighters is lessened, and a slow methodical examination of the occupancy can performed. In this instance, the incident commander should assign firefighters to search specific areas of a building. This will increase accountability and ensure a thorough search. For example, in a 2½-story building, if there are two companies available for search assignments, one company is assigned to search the first floor, cellar, and perimeter of the building. The other company may be assigned searches of the top floor and the attic. The searches should start at the point of fire origin and work outward.

Primary and Secondary Searches

The incident commander must not get so carried away with the effort to extinguish the fire that the search for victims is overlooked. One of the most important orders given by the incident commander is the assignment of primary and secondary searches.

The primary search is the first search of a fire area. It is performed in a quick, systematic fashion during the fire extinguishment stage. When conducting a primary search, firefighters should examine the areas that provide the greatest chance of finding a victim. Most fire survivors are discovered during the primary search (fig. 24–2). At a room-and-content blaze, fire victims may be found in a burned-out room or in a hallway leading from the fire room to an exit window or door. At some fires, victims flee to a bathroom, seeking the protection of the water.

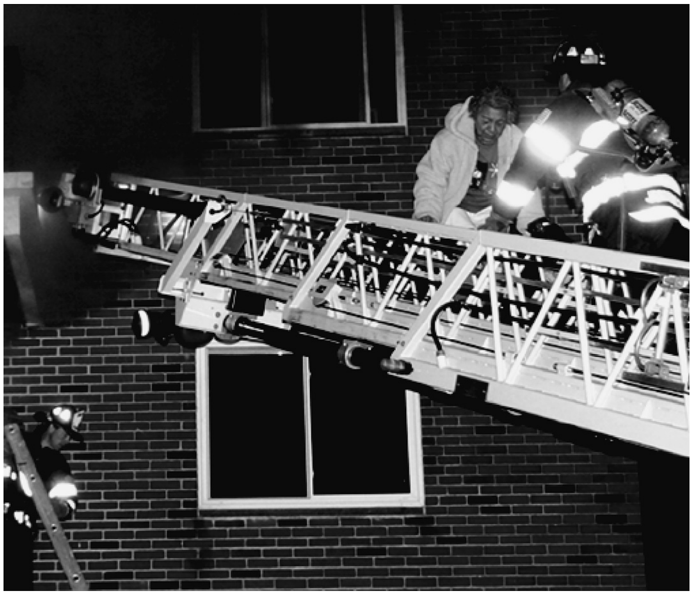


Fig. 24–2. A woman removed from a burning building during a primary search.

A secondary search is a slower, more thorough search of the entire fire building and the area around the building. This search will include the same area as the primary search plus adjoining bedrooms, the floors above and below the fire if necessary, and the outside area around the perimeter of the building, where people trapped by flames could have landed after jumping out windows.

After the searches have been completed, the results are reported to the officer in command. The primary search, having been conducted during the hectic fire extinguishment stage and in close proximity to the fire and heat, may overlook a fire victim in a concealed location such as in a closet, under a bed, or outside in the bushes. However, the secondary searches must find the fire victims, no matter their location. When conducting searches, the incident commander should interview neighbors and family members. Their input as to whether there are missing persons can be used by the incident commander to determine if anyone is missing at a fire. However, even if neighbors say no one is home, primary and secondary searches should still be conducted.

Search Standard of Performance

There should be a time standard of performance for searching. The time standard is a reasonable time in which responding firefighters can locate a fire victim on the basis of the number of firefighters at the scene, the size of the building, and the size of the fire on arrival. This time standard of search-and-rescue performance is necessary because victims burned and overcome by smoke have a limited survival time before they must receive medical care. For example, a performance standard of search time in an urban residential area, where ladder companies are available to search on arrival simultaneously with the hose line attack, might be 15 minutes after arrival at the scene. However, in a community where there are no ladder companies and response time is 15 minutes or more and when firefighter can perform a search only after fire extinguishment, a standard of performance for discovering a victim would be longer.

A standard should be based on the past experience of the local fire department. The standard time required for victim recovery in a dwelling could be 30 minutes, assuming that the response time is 15 minutes.

Search standard times in a high-rise buildings are even longer, mainly due to the size of the buildings. There can be 150 small, smoke-filled perimeter offices, cubicles, stairways, elevator lobbies, and storage areas that need to be searched. Also, there may be several floors above and below the fire that are filled up with smoke. A high-rise office building designed with an HVAC system can spread smoke 5–10 floors through the ductwork, even if the air system has been shut down. Elevator shafts will allow a stack effect (natural air movement inside a high-rise building due to the difference in temperature inside and outside) to move smoke 10 floors and then mushroom out on a remote office floor. Also, in a high-rise after a serious fire, when doors are opened by firefighters or by occupants fleeing the blaze, 10–15 floors of the stairwell can be full of smoke. Stairs must be searched for victims. In all, it may take ½–2 hours after a fire is under control to complete a secondary search.

When establishing standards of performance for search times, there must be an understanding that special conditions of any fire or any building can delay the search time. If fire victims are not discovered with these standard performance times, there could be a logical explanation for the delay. For example, a smoke-filled high-rise, a collapse in a residential building, a difficult forcible-entry operation that delays entry, or an intense fire that takes hours to extinguish before a thorough search can begin, will all result in an extended search time. At a fifth-alarm fire in the Empire State Building, I used four battalion chiefs, six engine companies, and six ladder companies to conduct a secondary search. The fire was extinguished in 30 minutes, whereas the secondary search took 1½ hours to complete.

Primary-Search Strategy

Before and after a fire is extinguished, firefighters start the primary search. From the moment firefighters are on the scene, the primary search is underway. Firefighters may have other assignments, but they are always looking for victims. Sometimes all they can do is report their location to the incident commander and continue their assigned duties. However, the search is ongoing.

After the blaze has been extinguished, the search becomes more organized and intensifies. The primary search should start in the area of fire origin. For example, if the fire starts in a 2½-story dwelling on the second floor, the primary search starts in the room of fire origin, then moves outward, toward exits such as fire escapes, windows, or doors. All adjoining bedrooms in the apartment are searched during a nighttime fire.

After the entire fire floor, including bathroom and closets, has received a primary search, the floors above and the attic are searched. Heat and toxic gases rise. Victims are often found lying on the stairs and in rooms directly above the fire. In a multistory residence, all the living areas on the floors above must be included in the primary search. Unless there is a skylight or scuttle cover over the stairs and it is vented by a firefighter operating on the roof, smoke, heat, and gases from the fire anywhere in the building will rise up the open stairway and mushroom out on the top floor. The top floor and the attic are where fire victims some distance from a lower-floor fire will be found. Searching firefighters should follow the smoke when searching for victims.

Primary and secondary searches of specific designated areas, by specific companies, should be ordered by the incident commander. On completion of a primary or secondary search, a report should be transmitted to the incident commander, stating the location searched and the results of the search. If the search result report is not received in a timely fashion, the incident commander should request a search progress report.

In some fire departments, the units responsible for searches and the areas to be searched are preplanned in a standard operating procedure. For example, in a fire department that has several ladder companies responding to a fire in a multiple-dwelling building, the first ladder company to arrive may be preassigned search responsibility for the fire floor and the perimeter of the building, and the second ladder to arrive may be preassigned responsibility for searching all the floors above the fire apartment.

Secondary-Search Strategy

A secondary search is the more thorough search that is conducted after the primary search. Moreover, a secondary search is a slower and final search. This search includes the entire building and the outside perimeter of the building, to find people who might have jumped out windows and the interior shafts. Secondary-search reports should include the area searched and the company or firefighters conducting the search. This information ensures accountability. Results of the final report must be given to and recorded by the incident commander.

A secondary search is usually completed when the fire is placed under control. However, at a major-alarm fire where there is a possibility of victims, the secondary search does not have to be completed before the fire is under control. A fire may be extinguished and the blaze declared under control while the secondary search continues for hours.

At some fires, the destruction to the building is so great that there is a danger to searching firefighters and little possibility of anyone surviving inside the burned and collapsed structure. In this situation, if in the opinion of the incident commander a secondary search cannot be completed, a report should be sent to headquarters over the radio, stating that the secondary search cannot be completed owing to a collapse danger. A written entry about the incomplete search and the reason for the search ending should be made in the company record book and on the fire report. This documentation is necessary in case of possible legal action in the event that a buried victim is later discovered.

Common Areas of Victim Discovery

Many articles you read about conducting a search for victims after a fire emphasize the unusual or out-of-the-way places to search, where victims may be found hidden from view. Examples include in closets, under falling clothes; under a bed; wedged between a bed and a wall; behind radiators; in bathrooms; in the bushes, around the perimeter of the house; at the bottom of light and air shafts.

While that is good training information, when searching, do not forget the obvious areas in which victims are most likely to be found—especially the point of fire origin. Most fire victims will be found close to the point of fire origin. The closer you are to the smoke and fire, the more likely you will be injured.

For example, at one serious early-morning fire in a multiple-dwelling apartment building, a neighbor in the street told the incident commander that an old man lives in the apartment. The chief at the command post immediately announced over the portable radio that there was a report of an elderly man in the burning apartment. All firefighters heard the chief's radio report. As soon as the flames were knocked down, firefighters fanned out and started searching for the reported victim. They searched everywhere—in every closet, in all the dark corners of the rooms, under every piece of furniture in every room, in the hallway, and in the bushes outside the building. No victim was found.

The search results reported to the chief were negative, but the neighbor insisted that an old man lived in the apartment. Another secondary search was ordered by the chief. Firefighters again searched every corner of the burned-out apartment. Every square foot of the blackened and charred apartment was methodically searched again. The results of this second secondary search again were negative. Finally, the chief and the firefighters decided that the man must have left the apartment that night. They began to overhaul the burned-out bedroom. As they began to remove the charred and burned bed to discard it out the window, they discovered the small body of the elderly man, burned to a crisp and sunken into the large mattress.

Fire victim study

During the 1970s and '80s, a fire-fatality study was conducted in the Bronx. The FDNY, 7th Division, had experienced a large number of fire fatalities in residential buildings. The study showed that most fire victims were discovered during the primary search in and around the point of fire origin. The next most common area in which victims were found was in a path leading from the point of fire origin to an exit: the victim had tried to escape the flames and crawl to a window or a door but collapsed on the way. Fire and smoke victims sometimes fled into a bathroom, seeking the protection of water. At nighttime fires, victims in apartments were often found in adjoining bedrooms dead in the bed. In fires in private dwellings, victims were sometimes found on upper floors or in attics. Sometimes, unable to descend the open stairway filled with smoke and heat, they jumped out of windows. Smoke and heat in a fire in a 2½-story dwelling will flow up the large open stairway and mushroom out on the upper floors.

Search strategy for commercial buildings

In commercial buildings, such as stores, people shopping and unfamiliar with exits sometimes take refuge in a cellar. Unable to escape, they die in the cellar among the merchandise. Smoke and toxic gases can be blown down a large open cellar stairway by the hose stream fire attack.

People attempting to escape also die in stairs during a fire. This happens when doors to stairways are propped open by stock or wedges to improve ventilation. Some stair doors (except for the street level) in commercial buildings are allowed by law to be locked. If people escaping a fire enter a stairwell, which then fills up with smoke, they may not get back into the store and will die locked in an exit passageway. Search the stairs above and below grade for trapped victims.

Search strategy for high-rise buildings

During a fire in high rise buildings, victims may be found stuck, between floors, in smoke-filled elevators. Fire victims may also be discovered on the floor in lobbies, where they waited in vain for the elevator. If no fire drills are held by management, then people who work in a high-rise building and use the elevator every day may not know the location of the exit stairway that they are supposed to take during a fire.

All stairways must be searched in a high-rise building after a fire. Every stairway must be searched, from the top to the bottom landing. Many people see highly dramatic television programs on which people are rescued from fires by helicopter and when evacuating during a fire often incorrectly up a stairway to escape a fire, instead of going down the stairs to get below the fire floor. All stairs in an office building do not go up to the roof level. Some stairways dead-end at a lower floor or terminate inside a large, dark machinery room. Regardless whether an individual survives the walk up the smoke-filled stairway, there will invariably be no air rescue, because most roofs are not designed for helicopter landing.

Today, people do not know how to react to a fire in a high-rise building. The fire service must do a better job of fire safety education. People must know what to do when inside a burning high-rise building. Sometimes, it is best to stay in the apartment or office. During a fire in a high-rise office building, the people closest to the fire, those on the fire floor and the floor above, may be told to leave. Everyone else on the other floors should stay put. During a fire in a high-rise apartment building, it is different. Everyone should stay in their apartments. Stairways and hallways fill up with smoke; an apartment is safer during a fire. Therefore, in a high-rise office building, the strategy is a partial evacuation, and in a high-rise apartment house, the strategy is that no one leaves except the person whose apartment is on fire. The building management should announce over a public-address system the fire chief's instructions to occupants during a fire.

At a high-rise office-building fire, the area of fire origin must be searched before the surrounding areas—that is, move outward from the fire origin when searching. The outer-perimeter offices are areas where victims will be found dead and injured. They are seeking shelter from a fire in an open floor area. Victims will try to get to a window and signal for help. Unfortunately, the windows in most modern high-rise office buildings are sealed. The bodies of fire victims may be found slumped below the sealed windows in the perimeter office. If a window is broken in an outer office, notify the incident commander and check the set-back balcony below (if one exists) or the street for possible jumpers.

Discovering a Fire Victim

When a seriously injured or dead fire victim is discovered during a search, the incident commander should be immediately notified. The apparent condition of the victim should accompany this radio notification. There are three conditions of a fire victim discovered during a search: obviously dead; seriously injured and unconscious from smoke burns; and injured but able to walk. First aid must be administered when needed, and medical personnel should be immediately called for. In all cases, an examination is conducted. Only a medical professional can officially pronounce a person dead.

Transportation of Fire Victims

When a victim is discovered, first aid should immediately be administered to ensure breathing, control bleeding, and prevent shock (fig. 24–3). A resuscitator should be immediately summoned and used after CPR. The victim should not be carried physically by firefighters.

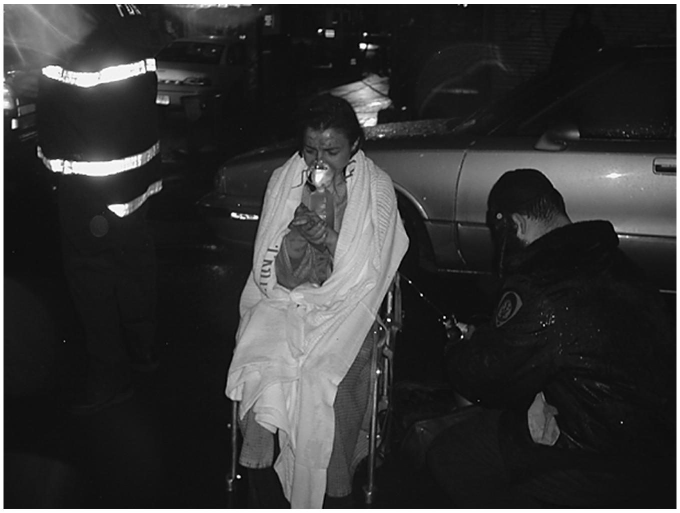


Fig. 24–3. Firefighters must care for victims removed from fires.

Photographs show unconscious victims being carried out like sacks of potatoes—one firefighter carrying a person's shoulders, another firefighter holding the legs. This is not considered proper transportation of the injured. I learned a lesson as a rookie firefighter one day in a smoky cellar, when a fire victim was examined and confirmed dead. One firefighter said, "Grab his legs. I will get his shoulders," and a veteran officer said, "Hold everything! Let's do this right." Even though the man was obviously dead, we transported him from the smoky cellar to the ambulance in the right way. The officer ordered a Stokes stretcher blanket and a resuscitator. We placed the victim in the stretcher, covered him with blankets, and secured the straps so that he would not fall out. Then, the officer placed the resuscitator in the stretcher, with the face piece on the victim, and four firefighters carried him up the cellar stairs.

Another fire transportation of fire fatalities was a major event. We had discovered five fire victims in a high-rise apartment. They were declared dead by medical personnel at the scene, but we did not have equipment on the scene to transport all five victims at one time. The chief decided not to transport first one, then sometime later the others. They were all dead, so there was no rush. The mayor and many journalists responded to this fire. The radio reports confirmed the fire deaths. The chief kept the victims in a room until we obtained all the necessary stretchers, blankets, and resuscitators at the scene. Then, all five victims were properly placed in the stretchers, blanketed with resuscitators, taken out of the building, and moved into the ambulance all at once. The city officials and the press understood the seriousness of the fire when all the victims were transported out of the building together by firefighters.

Investigation of Fire Fatalities

The incident commander must investigate every fire fatality. The firefighters and the officer of the company that discovered the victim must document the particulars of the fire injury and death: who discovered the victim, where the victim was discovered, and what firefighting tactics the firefighter was performing when the victim was discovered. If the fire victim is alive, does the discovery of the victim warrant a meritorious award to the firefighter?

The investigation will also be valuable as a firefighter-training tool. A full report—including the person's name, age, address and apartment number, and other particulars—should be made. This document may be important if there is a legal action based on the fire.

Also included in the investigating report following up a fire injury or fatality should be a diagram of the location where the fire victim was discovered. The entire fire area should be included in a diagram. This diagram will provide valuable information for fire prevention and fire education studies in your community. When a fatal-fire drawing is made, the path that the hose line takes when it is advanced inside the fire room should be shown on the report. This can be shown by using a long dashed line, with an arrowhead indicating the nozzle end. The exact position in which a fire victim's body was found by a searching firefighter is an important factor for analysis. It tells whether the victim was attempting to escape or was overcome in sleep. A cross best depicts the victim's body; the small portion of the main stem of the cross represents the victim's head, and the cross section represents the arms. Another important factor that must be indicated on the diagram is whether the victim was found lying faceup (supine position) or facedown (prone position); this is indicated on your drawing by placing the letter S (for supine) or P (for prone) next to the cross. If facedown, the victim may have been escaping the fire; if faceup, a sudden blast of heat may have driven the victim backward.

All details of the immediate fire area should be shown in a drawing of a search-and-rescue operation or a fatal fire. Diagonal lines again show the flaming area; the point where the fire originated is designated by a triangle. The floor of fire origin may be different from the one on which the rescue is conducted or where the victim is found, so the floor number of the floor of origin is placed inside the triangle. The path of entry and exit by the firefighter is depicted by a solid line. A small dashed line without an arrowhead at the end shows the escape path that the firefighter takes when removing the victim. Fire escapes, porches, windows, doors, and interior partitions of the fire occupancy should be included in all diagrams. Room sizes to the nearest foot must also be shown. When two diagrams are prepared, the northerly direction must be indicated on both, so that they can be related to each other and easily analyzed.

In some fatal-fire reports, it may be necessary to show apparatus positioning. There are many sets of symbols used on a fire diagram. The Sanborn map symbols listed in the *Handbook of Fire Protection*, published by the National Fire Protection Association. are widely used. Other symbols used to denote fire apparatus are as follows: for an engine company, a rectangle is used, with the company number inside the rectangle. A pumper is usually positioned at a hydrant, and a hose line is shown coming from the pumper to the fire by a solid line, with an arrow depicting the nozzle. A portable deluge nozzle can be shown on the diagram by an oval or half-circle also containing the unit number of the company operating the master stream. An aerial ladder is designated by a rectangle containing the unit number and a ladder shown extending from the rectangle.

The fire diagram is accompanied by a written report. This report must be thorough, conveying all the available details. It should be the equivalent of a police detective's report of a shooting victim. A fire ground drawing or diagram can convey information or provide dramatic emphasis that cannot be achieved in text. Many of the questions presented by a spreading fire or a fire death can be answered with reference to the layout of the burning building. The size and construction of a structure and the size of the flaming area shown in a fire ground drawing are vital to any inquiry or investigation.

Accountability

The radio report of a secondary-search completion must include the area searched and the company or firefighters conducting the search. This is necessary for accountability. An incident commander must order searches made to specific areas if necessary and must determine the results of such searches as soon as possible after the fire is extinguished.

25 EVACUATING PEOPLE FROM BURNING BUILDINGS

Most people escape from a burning building by themselves (fig. 25–1). They leave without assistance of the firefighters, and they help each other out. However, when firefighters arrive, there may be children, old people, and disabled people left behind inside the burning building. These unfortunate ones must be protected from the spreading fire by being assisted out of the burning building. There are three strategies for removing people inside a burning building from the path of a spreading fire:

Fig. 25–1. Most people leave a burning building unassisted.

- Evacuating people at the same time as you fight the fire
- Evacuating people and not fighting the fire
- Not evacuating the people and fighting the fire while the people stay inside the burning building

Evacuating People and Fighting the Fire

If enough firefighters are on the scene, the incident commanders' strategy may be to fight the fire and evacuate the people from the burning building at the same time. A medium-sized or large fire department that has sufficient personnel can conduct firefighting and evacuation at the same time. When there are enough firefighters ready for action, an engine company can stretch the hose to the fire and extinguish the blaze while the ladder company firefighters perform search and rescue and evacuation at the same time.

This strategy can be accomplished when the burning building is a private dwelling or a low-rise ordinary-constructed building and there are not many people to be removed. People who are closest to the fire are removed and evacuated first. After people on the fire floor and directly above are removed from harm's way, during the initial hose line attack by firefighters at a routine fire that looks like it will be readily controlled, it is better for occupants several floors above to stay in their apartments than go into the hallway or stairway. However, if the fire is not controlled by the firefighters and it appears to be spreading, the incident commander must change strategy. Now all the occupants are evacuated from the burning building. Ladders and fire escapes must be used to remove all the people. People are not taken down the main stairway, in which the firefighters are battling the fire. If the firefighters cannot stop the fire and the building is not fire resistive, it cannot be depended on to stop spreading flame or smoke. A defend-in-place strategy is not an option, and all people must be removed from the burning building.

Evacuating People and Not Fighting the Fire

An incident commander of a small rural department that does not have the advantage of unlimited resources may decide to evacuate people from a fire and not conduct fire extinguishment operations at the same time. This could occur if on arrival, people are trapped at windows and about to jump. In this instance, the incident commander's strategy could be to rescue the people and delay firefighting operations.

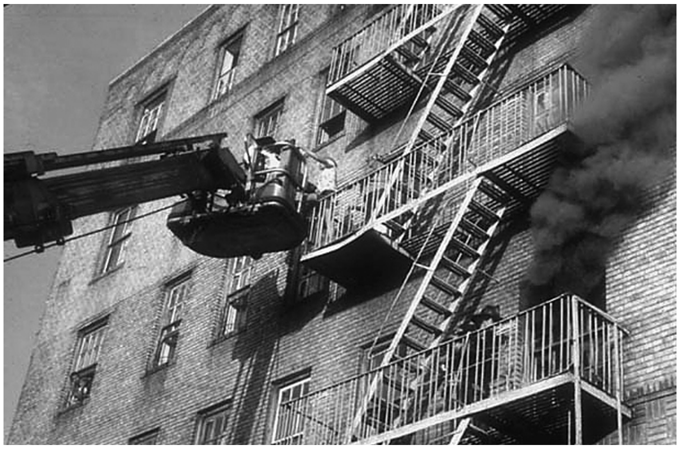


Fig. 25–2. A large fire department can fight a fire and evacuate occupants at the same time.

As soon as more firefighters arrive, the fire-extinguishing operations should start, because there may be more people trapped inside the burning structure that cannot be seen during an outside size-up. For a fire department to be capable of occupant removal and firefighting simultaneously, they would require three things:

- At least 15 firefighters at the scene
- A good water supply
- At least two fire apparatus: an engine company and a ladder company (fig. 25–2)

The National Fire Protection Association's Firefighting Response Standard calls for a minimum of four firefighters on a fire engine or ladder truck. And this four-person minimum response on the initial alarm is expected to arrive by 6 minutes after the alarm was transmitted. Within 10 minutes of the alarm transmission, the standard calls for 15 firefighters to be on the scene. This is necessary for a full attack on a typical house fire. Included in the 15-firefighter standard are the following personnel:

- An incident commander
- A water pump operator
- Two firefighters on each of two hose lines
- Two support persons to help lay each hose
- Two people for search and rescue
- Two people to cut a hole in the roof or to vent windows to let out the deadly smoke and gases
- One person to operate the aerial ladder
- Two people standing by to rescue any trapped firefighters

In a small rural department with a single-pumper response manned by two or three firefighters, if there is no hydrant system, on arrival at a structure fire beyond the control of a single hose line, the strategy may have to be to evacuate people without fighting the fire. All three firefighters may rescue people until reinforcements arrive to start a fire hose stream attack (fig. 25–3).

Fighting the Fire and Not Evacuating the Building

Builders of high-rise buildings have imposed a defend-in-place firefighting strategy on the U.S. fire service. Instead of evacuating all the people in a fire-resistive high-rise building, firefighters fight the fire while people stay inside the building. Defend in place is necessary in a high-rise building containing hundreds of people; the alternative takes too much time and requires a number of firefighters that even the largest fire departments could not muster. Designers of these tall buildings have told the fire service that evacuation of the entire building would take hours and be impractical and that the building will resist the spread of fire. This defend-in-place strategy was not a fire chief's idea. It was imposed on U.S. fire chiefs by code officials and design professionals of high-rise buildings.

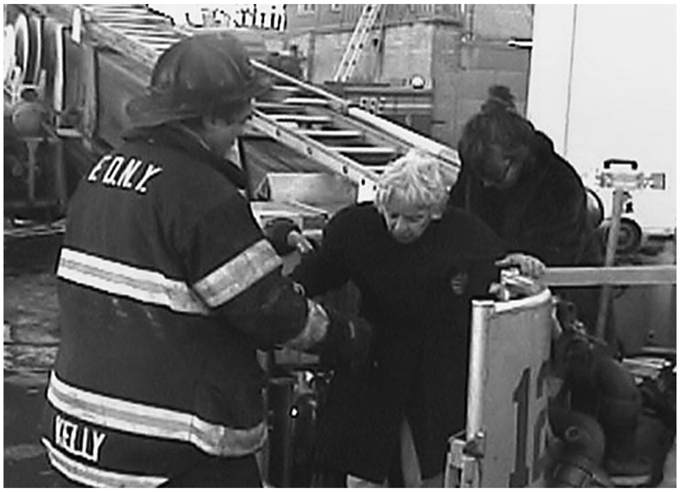


Fig. 25–3. Removing an occupant from a burning building takes firefighters away from firefighting duties.

To maximize the amount of rental space and minimize the cost of construction in the cities and suburbs, high-rise office and residential buildings are built as high as possible to house as many people as possible. Thus, during a high-rise building fire, hundreds of people cannot be evacuated from the burning building. In some buildings, it would take several hours. At the 1993 bombing of the World Trade Center, it took five hours for both towers to be emptied of all occupants. At a fire in a high-rise building, the incident commander's strategy must be to fight the fire while some people remain in the building.

A nonattack strategy was employed at the World Trade Center fire on 9/11. Once the incident commander decided this fire was beyond control of the firefighters at the scene and there were thousands of trapped occupants already in the stairs descending to the street, the strategy became a nonattack operation, concentrating on search and rescue and evacuation of occupants. When units arrived, they were ordered not to fight the fire but concentrate on search and rescue of people trapped in elevators, offices, and floors above the fire. All stairs were designated to evacuate people.

In some instances, a temporary nonattack strategy like this is used in a low-rise building when people are coming down the interior stairway and if the door to the fire apartment were opened, the people in the stairway above the fire would be burned. In this instance, the door is closed, and the people are safely taken down the stairway and past the fire. As soon as the people are below the fire, the fire attack begins.

Defend-in-Place Strategies

In a high-rise commercial building, the evacuation strategy is partial defend in place. In a high-rise residential building, the evacuation strategy is total defend in place.

Partial-defend-in-place evacuation

During a high-rise office-building blaze, the fire service must fight the fire while most of the people remain inside the burning building. This strategy requires the incident commander to evacuate the people closest to the fire—those on the fire floor and on the floor above. They are removed to safety below the fire. The commander then orders that all other people remain in the building unless smoke is entering their floor. If people are instructed to remain in the building, notify the chief that smoke is entering their floor by way of the HVAC system air ducts; that floor will also be evacuated, and firefighters will be sent to assist.

To use a partial-defend-in-place firefighting strategy, the building must be structurally sound—not about to collapse. Most important, the building must be fire resistive. You cannot order people to stay in place during a fire if the building will resist fire spread. The definition of a fire-resistive building is a structure that will contain fire on one floor and is subdivided with partition walls to confine fire and smoke spread to small manageable proportions. Fire must be confined to areas small enough for firefighters to extinguish with handheld hose streams. Floors and walls inside a fire-resistive building must contain fire and create areas of refuge in the building where occupants can remain during a fire.

Since the collapse of the World Trade Center towers and the revelation of weaknesses in high-rise fire-resistive construction—for examples, the spread of smoke through the central air system ducts—the partial-defend-in-place strategy for commercial buildings is now questionable. Fire-extinguishing strategy in high-rise commercial buildings depends on several conditions; the building must confine smoke and fire to one floor, and the fire must be a size that can be extinguished by firefighters. This means that the burning area must be less than

2,500 square feet. Firefighters cannot extinguish fire involving spaces over 2,500 square feet with one attack hose line. A further condition is that the people in the building must comply with the instructions ordered by an incident commander. Instructions for a partial-defend-in-place evacuation strategy must be delivered by the building management over a public-address system.

It is the opinion of many in the fire service, myself included, that many of these conditions necessary for the partial-defend-in-place firefighting strategy are not met in modern high-rise buildings. Today's high-rise office buildings with central air systems are not fire and smoke resistive. Fire and smoke will spread throughout several floors in the air-conditioning ducts of a high-rise. Also, firefighters cannot extinguish fires in today's large open floor areas of 10–20 thousand square feet by use of handheld hose streams. Finally, unless the occupants are highly trained in building evacuation procedures, they will not comply with the chief's instructions to stay inside a building during a fire. Since the 9/11 disaster, the public has lost confidence in the fire service. They will attempt to immediately leave the burning high-rise building, without regard to instructions to leave or stay.

Despite these problems associated with defend-in-place evacuation, the incident commander must proceed with this strategy. There is no alternative. The incident commander's strategy must assume that the building is fire resistive, that the firefighters will contain the fire, and that the occupants will comply with directions to stay or leave. After a fatal fire, the public and the lawyers may realize that a building is not really fire resistive, as it did not restrict fire and smoke to one floor and the floor areas were larger than the extinguishing capability of the fire service. Despite its weaknesses, partial defend in place is still the state-of-the-art strategy, agreed on by most experts in the fire service as the only available evacuation strategy for high-rise office-building fires.

Total-defend-in-place evacuation

The strategy for evacuating people from a residential high-rise is different than the strategy for evacuating people from an office high-rise. During a fire in a high-rise residential building, the fire must be fought while all people in the building remain in the apartments. No one is assisted to leave by firefighters. Unlike the office building, in a residential high-rise fire, everyone stays in place. No one leaves his or her apartment during a fire.

The evacuation strategy in a residential high-rise is a nonevacuation strategy. It is called a total-defend-in-place strategy. Everyone stays in the apartments except for the people in the fire apartment. If a high-rise extends above the reach of the tallest fire department ladder, the building must be made of fire-resistive construction. The definition of fire resistive construction is that the apartment walls and floors will resist the spread of flames and smoke for up to two hours.

In a high-rise residential building, there is no large open floor area: each apartment is subdivided by fire partitions, and if the door to the fire apartment is closed after the person leaves the burning apartment, flames and smoke should be confined to the apartment of fire origin. Flames and smoke will not spread throughout the entire floor as they would in an office building with a large floor space. Thus, during a fire in a high-rise residential building, the incident commander orders that all people remain inside their apartments while the fire is extinguished. Unfortunately, there is no way to do this. There is no communication system in a residence building as in a high-rise commercial building. Life safety and effective total-defend-in-place strategy require a public-address system in a high-rise residential building, to allow the incident commander to instruct people to stay in their apartments.

During a fire people must be ordered not to leave their apartments. They must be instructed not to enter the hallways or stairways because these areas will fill up with deadly smoke. The evacuation strategy in a high-rise apartment building is a total-defend-in-place strategy. The safest place to remain during a fire in a high-rise residential building is inside an apartment. In a fire in a high-rise residential building, the smoke-filled hallways and stairways are dangerous places. People who attempt to flee a fire in a high-rise apartment building are at great risk. There is more chance to die in a hallway or stairway than in an apartment of a fire-resistive high-rise apartment.

The key to the total-defend-in-place strategy in a high-rise residence building is the apartment door. Apartment doors must be equipped with self-closing mechanisms that will automatically close the door after the person flees a burning apartment. Postfire investigations where people die in hallways and stairways usually reveal that the self-closing device of the door to the fire apartment has been removed or dismantled in some way. Consequently, the door stays open during the fire, and the halls and stairs fill up with smoke. People do not realize the fire safety importance of this door-closing device. In some instances, apartment dwellers pay the maintenance people to dismantle the self-closing mechanism, to ensure that they are not accidentally locked out of their apartments while retrieving a delivery outside the door; as a result, they inadvertently create a deadly environment during a fire.

Evacuating People Down a Stairway

As soon as possible on arrival at a serious fire in a high-rise building where two stairways serve all the floors, the stairways must be divided by use. The incident commander will have to decide which stairway will be used for stretching the hose line to attack the fire and which stairway will be used for occupant evacuation. This is done even if the building is not being evacuated of occupants; firefighters will use the so-called evacuation stairway to search the floors above the fire. Whereas the attack stairway will fill up with smoke and heat, the evacuation stairway should remain free of fire and smoke.

During a fire in a commercial building, when the partial defend-in-place strategy is used, and people from the fire floor and the floor above are ordered to leave, they are instructed to use the evacuation stairway, not the attack stairway. All others are directed to remain in place on the other floors and not exit the building until notified by the incident commander.

At a fire in a residential building, no one is ordered to leave. Because such apartments have no central air ducts to spread smoke, all people except the fire apartment occupants can stay in their apartments and should not attempt to leave by the stairways. If high-rise residential buildings have central air systems with ducts connecting apartments, the total-defend-in-place strategy will not work. High-rise apartment buildings should have unit air-conditioners serving individual apartments with ducts. Total defend in place in a high-rise residence requires a public-address system in the building, so that the fire chief can speak to the people trapped above the fire. If there is no public-address system in a high-rise building to instruct occupants how and when to leave, there really can be no safe and effective fire evacuation of occupants. People have and will continue to die in the stairways and hallways because of lack of fire safety information.

Multiple-Dwelling Low-Rises

Multiple-dwelling low-rises are not generally fire-resistive construction. They are constructed of wood or brick and wood joists. Occupants of apartments several floors away from a fire in a four- or five-story multiple-dwelling building should stay in their apartments during the initial stages of a manageable fire. Firefighters will evacuate occupants close to the fire (e.g., in the burning apartment and the apartments directly above the fire) and fight the fire while others remain in place. The strategy is partial defend in place. This strategy is justified in a four- or five-story dwelling because the building has an enclosed stairway, fire-rated apartment doors, and fire escapes.

During the initial attack by the first hose team, it is usually best for people several floor above to stay in the apartments, rather than venture into the smoke-filled stairs or hallways. However, if the fire is not extinguished by the first attack hose line and starts to spread, all people in the building may have be assisted out of the building by firefighters using ladders and fire escapes, not the interior stairway. Unlike high-rise buildings, which are fire-resistive construction, low-rise buildings are combustible and have concealed spaces and poke-through holes. The floors and walls will not stop flames or protect people for more than a short time. Also, there is usually only one stairway in a low-rise multiple-dwelling building. There cannot be a total-defend-in-place strategy in a non-fire-resistive, low-rise multiple-dwelling building.

Private Dwellings

If a fire occurs in a private dwelling, all occupants should be immediately removed during the fire. People cannot stay in a private dwelling during a fire because there is a large open stairway and there are no fire escapes or second exits.

Stair Types and Evacuation Strategy

There are different kinds of stairways in a building, and there is a priority for stair use during a fire. Some stairways are more effective for evacuating occupants during a fire and emergency. Safety is a major concern when choosing a stairway for occupant evacuation. The priority for stair use to evacuate people in a burning building during a fire is as follows: smoke-proof stairways, enclosed fire stairways, scissor stairways, and access stairways.

First priority for occupant evacuation: Smoke-proof stairways

A smoke-proof stairway is also called a fire tower. Nevertheless, the term used by fire protection engineers is smoke-proof stairway, because it is more precise. A smoke-proof stairway is an enclosed stairway that requires people fleeing a fire to first pass through an open-air balcony or through an interior vestibule containing a smoke vent shaft or through an interior vestibule containing a vent shaft opening with a mechanical fan. The purpose of the open-air balcony or interior vestibule vent shaft in a smoke-proof tower is to dissipate smoke, heat, or flames, so that it does not follow the person entering the stair enclosure. For example, when a person leaving an office floor opens a self-closing exit door and enters the open-air balcony or interior vestibule, any smoke or heat following the occupant will dissipate into the atmosphere or up the vent shaft. The occupant inside the vestibule must open another self-closing door to enter the smoke-free stair enclosure. A smoke-proof stair will not fill up with smoke.

At a serious high-rise fire, when a fire officer decides which stairway to use for evacuating people above a fire and which stairway to use for attack and hose stretching. The smoke-proof stairway should be designated for evacuation—not for attacking the fire. This is because smoke-proof stairways, containing interior vestibules with vent smoke shafts are safest for the occupants to use. Also, smoke-proof stairs have created problems when used as attack stairs.

Experience has taught firefighters to use the smoke-proof stairway, which has an interior vestibule vent shaft, as an evacuation stairway to bring people down from above the fire, not as an attack stairway. At several fires, when the door from the vestibule to the occupancy was opened to stretch the hose line and attack the fire, heat and smoke swept into the vestibule and was sucked up the vent shaft; smoke overflow from the vent spread up the smoke-proof stair enclosure. Firefighters temporarily trapped above one such fire were forced to retreat back into the enclosed tower and to the floor below.

Second priority for occupant evacuation: Enclosed stairways

An enclosed stairway has walls rated to resist fire for two hours and self-closing doors (rated at one-hour fire resistance); an enclosed stairway does not have an intermediate vestibule. When you open the door from the occupancy, you enter the stair enclosure. Heat, smoke, and flames follow people entering an enclosed stairway when the door is open.

Doors leading to enclosed stairways have spring hinges. These hinges automatically close the doors after opening. This self-closing door is designed to limit the amount of smoke and heat that can enter a hallway or stairway when the door is opened. However, when firefighters use an enclosed stairway to attack a fire, they must hold the self-closing door open. This allows tremendous amounts of smoke, heat, and flames to enter the stairway and can trap any occupants or firefighters above the fire. Thus, if people are descending the stairs, do not open the door to attack the fire, so that you will not trap them in the stairway above the fire. Life safety is the first priority of firefighting; fire containment is a second priority.

Third priority for occupant evacuation: Scissor stairways

Some enclosed stairways are constructed as scissor stairways. This is two stairways built inside one stair enclosure. The stairs crisscross inside the single stair enclosure. The integrity of each scissor stair depends on the partition walls that enclose the two stairs. If there are unauthorized openings in the enclosure partition or if there is no partition between the stairways, they may both become contaminated with smoke.

Fourth priority for occupant evacuation: Access stairways

Access stairways are open stairways. An access stairway is not designed to be an exit. Indeed, it is not an exit. There is no enclosure around this stairway. Access stairways are decorative stairs, usually found in commercial buildings near executive offices or in duplex apartments. These unprotected open stairways connect several floors, allowing people to move between floors without requiring them to go out to the public hallway and use the elevator or the public stairways. Access stairways spread fire, heat, and smoke from floor to floor. They do not go to street level.

Area of refuge

When you remove people from the danger of a spreading fire in a burning building, you take them down a stairway, to the street. However, take old, injured, or disabled persons two or more floors below a fire and leave them there. They will be safe, because fire and smoke spread up, not down. However, if the stability of the burning structure is in doubt, remove the people from the building entirely. When outside, have police direct them beyond the collapse danger zone.

Horizontal evacuation

Since fire, heat, and smoke rise, people are directed to evacuate down a stair or ladder below the fire, heat, and smoke. Occupants are never taken up a stairway, above a fire. However, there are times when you do not take them below the fire, but instead move people in a horizontal direction, away from the fire. During a fire, you may move people behind a fire-resistive barrier into an area of refuge. This is horizontal evacuation. It is a strategy used in buildings containing people who are old or infirm and are not able to use stairs. Horizontal evacuation is used in hospitals, schools, places of public assembly, and prisons. These buildings are constructed in sections. Fire-resistive walls and doors that can stop flames and smoke subdivide each section. Once safely in the area of refuge, the people may or may not be taken down the stairs to the street.

Firefighter-Assisted Evacuation

There are priorities as to how firefighters should assist people from a burning building using emergency evacuation methods. People should always be removed from a burning building in the safest possible way. A firefighter can increase the victim's risk of death and injury by the way the person is removed from the fire. If the stairway cannot be used, alternative methods should be used to remove people from a burning building are: a fire escape should be the first priority; an aerial platform should be a second priority; an aerial ladder should be the third priority; and the last resort is a rope rescue.

26 MASTER STREAMS

When the firefighting strategy of using two or three interior hose lines fails to extinguish the fire, a defensive strategy using master streams must be put into action. At other times, if the fire is too large on arrival, a hose line strategy cannot be implemented; instead a master stream attack strategy must be used from the start. In this instance, the strategy is to rescue the people and position master streams around the four sides of the burning building and extinguish the blaze with large quantities of water. The master stream is an extremely effective firefighting machine. The large-caliber stream has saved many firefighters' lives and has prevented the destruction of millions of dollars in property. However, if it is not used properly, it can be a destructive force.

Definition of a Master Stream

What exactly is a master stream? A fire department master stream is a ground-based or aerial device with a fog or straight stream capable of delivering water at a rate of more than 300 gallons per minute to a fire (fig. 26–1).

Handheld nozzles attached directly to a hose line delivering this amount of water volume and pressure are too difficult to control and direct, so mechanical, electrical, or hydraulic assists are required. Fog streams with a delivery rate of more than 300 gallons per minute and solid-stream nozzles of 1½ inches or more in diameter are considered master stream nozzles.

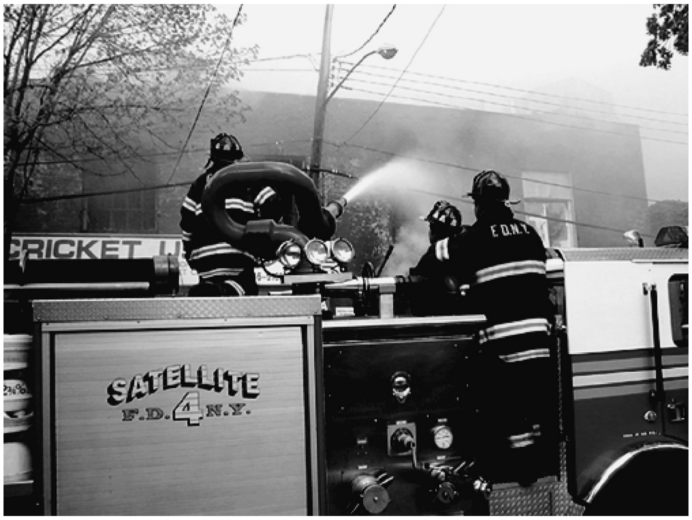

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Fig. 26–1. A master stream delivers water at a rate of over 300 gallons per minute.

There are two types of master streams: ground master streams and aerial master streams. Ground master streams include deck guns mounted permanently on top of apparatus and portable deluge nozzles that can be operated from atop an apparatus or positioned on the ground, closer to a fire. Aerial master streams are master streams mounted on top of ladder pipes, snorkels, and aerial platforms.

Positioning Master Streams

When the decision has been made by the incident commander to use a master stream, it is important to position the apparatus correctly, so that the large-caliber water streams are used for greatest effectiveness. The first consideration for positioning a master steam is access to the fire. The master stream must be positioned where firefighters can hit flames with the water.

When access to the fire is not a consideration and the burning building stands alone (i.e., there is space around all four exposures), the first apparatus should be positioned at a flanking exposure near the downwind side, so that the large stream can stop the spread of fire. The second apparatus to be used for the master stream should be positioned on the other flank, near the downwind side, to stop fire spread and contain the fire. The third master stream should be set up at the upwind side of the fire, for further encirclement. When the heat, fire, and smoke conditions permit, the fourth aerial master stream is positioned at the downwind side of the blaze. All four exposure sides are now covered, and all streams are directed to extinguish the burning building.

The strategy for positioning master streams is the same as positioning hose lines: life safety first. Flank the fire and do not expose firefighters to the downwind side. Next, stop the spread of the fire on each side, and eventually confine it on all four sides. Finally, extinguish the fire.

In some instances, the burning building is one of several in a row, and there is no space around the building. Here, the first master stream is positioned in front of the building. The second master stream is positioned at the rear of the fire. When the apparatus to be used for a master stream is positioned in front or rear of the building, and there is a danger that a wall may collapse and fall outward, the incident commanders should order that the master stream apparatus be positioned outside the collapse zone or in a flanking position. That means that the officer should position the apparatus on the side of burning building, away from the entire wall of the burning building. If a portable deluge nozzle or an aerial platform is placed in front of an adjoining building, the range of the stream, which is operated at an angle and directed at a window, doorway, or rooftop of the burning building, may be limited; however, the firefighters operating the stream will be in a safe flanking position. Also, when there is a danger of wall collapse, the aerial streams should be operated above the wall, so that the firefighters in the raised bucket will be above the collapse danger.

Aerial streams operated by firefighters above the roof and directed downward at the fire will also be less effective, but firefighters in the bucket at the tip of the ladder will be safely above the collapse zone of a weakened wall. Sure, when there is no danger of wall collapse and aerial master streams are needed to control a large body of fire, the firefighters may operate the aerial platform bucket nozzle close to the flaming windows of the building for effective penetration of the master stream (fig. 26–2).

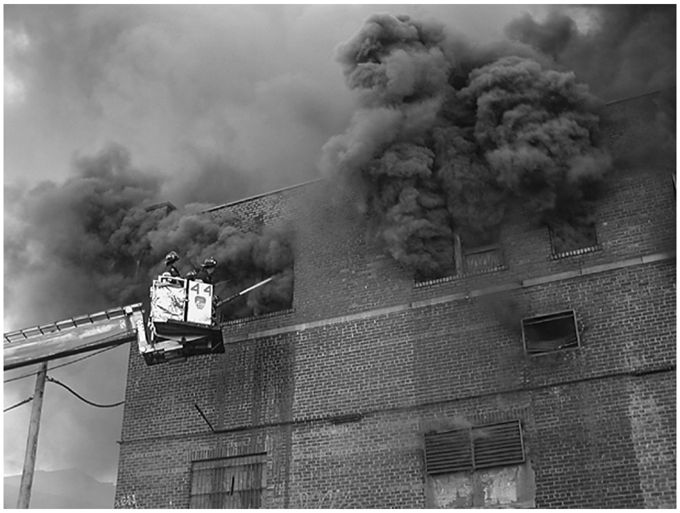

Fig. 26–2. Operating close to a window is effective for deep penetration of a master stream.

The priorities of positioning apparatus are life safety first, including the lives of firefighters, and fire containment second. That rule never changes.

Master Stream Strategies

There are two strategies for master stream use. One is using a master stream for a temporary knockdown of a large body of flame. In this strategy, firefighters inside the burning building are withdrawn and then reenter to conduct interior firefighting when the master stream is shut down. The second strategy is to use an exterior master stream attack during the entire operation; no firefighter is inside the burning building during the master stream attack.

During the first master stream strategy, a temporary knockdown, the incident commander must confirm that all firefighters have withdrawn to a safe position before the master stream is used. Interior forces must be withdrawn to the floor below or outside the building, before the large-caliber stream is directed into the burning building. It is not enough simply to order all companies to withdraw; the chief must wait for the officer directing operations inside the building to confirm the safe withdrawal before ordering the master stream into use.

When master streams are put into operation for long-duration, total extinguishment of a fire, not just for a quick knockdown, the force of the high-pressure streams and the weight of the water poured into the building over a long period may weaken the structure. The incident

However, conducting a close-up approach into a window, beneath an unstable wall in danger of collapse, should not be done; an effective fire extinguishment operation can never supersede firefighter safety.

At one of my last major fires before retirement, a fire in a row of stores in the Bronx, a parapet wall collapsed into a bucket of an aerial platform, seriously injuring several firefighters. The wall collapsed on the tower ladder bucket, containing two firefighters. The ladder was getting into position to use the aerial master stream at a fifth-alarm fire. The apparatus had been repositioned in front of the fire building, and the chauffeur positioned the ladder truck outside the collapse zone. However, the bucket was raised from the bed and lowered to the sidewalk, inside the collapse zone, so that two firefighters could climb into the bucket. Right before it was to be raised so the stream could be used, the wall collapsed. The two firefighters had just opened the swinging door and stepped into the bucket when the wall came crashing down on them. One firefighter suffered a concussion, and the other had a broken collar bone and a dislocated shoulder.

commander must prepare for eventual collapse of the building. The chief must not only withdraw all firefighters operating inside the building before using the master streams but also order those working around the perimeter of the building to move beyond the collapse zone. The collapse zone is a distance away from the unstable wall equal to the height of the wall. A collapse is more likely to occur during the long duration use of a master stream.

Close-up Stream Direction

When an aerial master stream is to be used for a quick knockdown, the master stream nozzle is most effective when placed close to the window of the building. This close-up position can give the stream deep penetration and its widest horizontal range inside the floor area. The large, burning open-floor area of a supermarket or factory floor can sometimes be quickly extinguished when the master stream is positioned near the window opening and the stream sweeps the floor.

The close approach of an aerial stream is an effective operating procedure, unless the front wall of the fire building appears to be unstable. When there is a danger of structural collapse, no part of the aerial stream bucket and/or nozzle should be positioned where it could be struck by a falling wall (fig. 26–3). When this fire ground precaution is not heeded, firefighters in the bucket of an aerial platform can be buried with bricks, have the bucket torn from the apparatus boom, or have the ladder tipped over on its side by the weight of a collapsing wall. Aerial master streams and tower ladder buckets must be operated outside the same collapse danger zone from which firefighters on the street operating hand lines have been withdrawn.

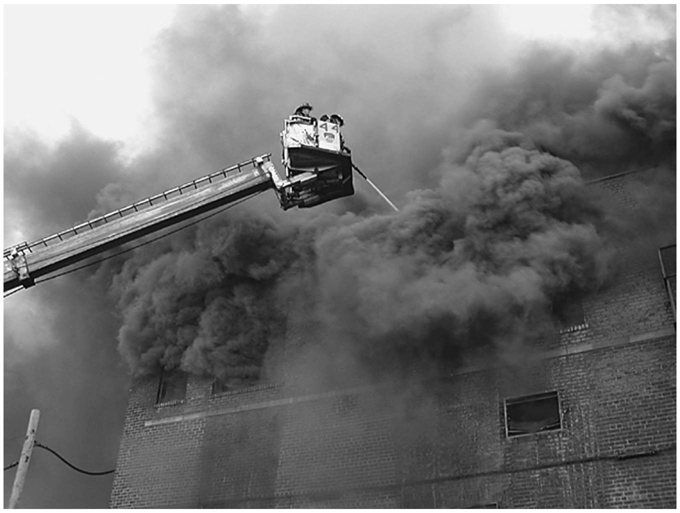
Fig. 26–3. When there is a danger of wall collapse, operate the aerial master stream from above the unstable wall.

Strategy Change

Before any type of master stream is put into operation, the incident commander should ensure that the powerful stream will not injure any firefighters inside. A master stream delivering into a burning apartment can create steam that can burn firefighters operating hose streams inside. A master stream can puncture an eardrum or knock firefighters down a stairway or off a roof.

The safe transition from an interior hose line attack to a defensive, exterior master stream attack requires four critical elements:

- Effective communication between the incident commander in the street and the interior operations officer. Portable radios must work.

- An interior operation officer in command of the firefighters inside the burning building who are operating interior hose streams. This officer must insist that the firefighters inside withdraw to safety.
- An incident commander who understands the never-changing priorities of fire ground strategy: protection of lives (including firefighters'), fire containment, and property protection.
- Firefighters operating the aerial stream and the supply pumper, who wait for the order to start water from the incident commander. Coordination among all three is critical for effective master stream use.

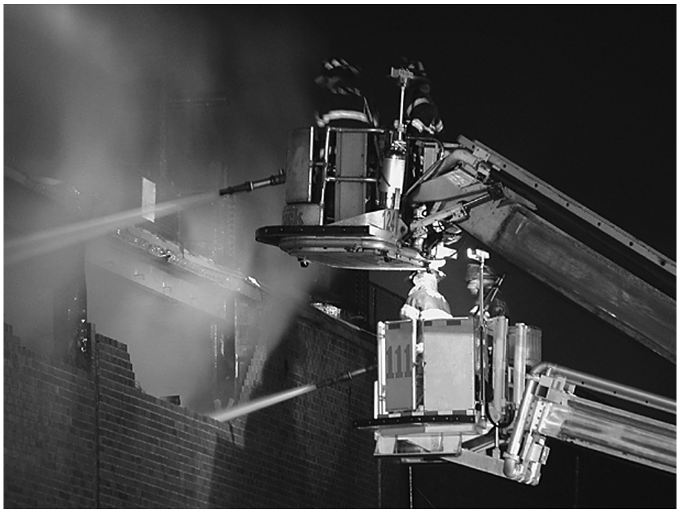

Fig. 26–4. A powerful master stream can collapse walls.

Impact of Master Streams

The incident commander must understand that the master stream is a powerful force and when used improperly can collapse buildings. The destructive effect of a master stream is greatest where the water leaves the nozzle. Large-caliber streams from deck guns on pumpers travel some distance before reaching the burning building. In the past, to get a proper stream angle (32°) for maximum stream reach, pumpers were placed away from the burning target—usually across the street. Today, for maximum effectiveness, the aerial master stream nozzle is maneuvered close to a burning building.

Parapet walls, chimney tops, copestones, cornices, and roof dormers, can be weakened and collapsed by this necessary close-up approach of the master stream nozzle as it is directed from target to target. Firefighters working near a burning building where an aerial stream is operating can be struck by flying fragments that have been knocked loose from the building by the powerful aerial stream (fig. 26–4). A veteran firefighter who frequently used a tower ladder stream told me once, "I can use the impact of aerial master stream and cause a three-story frame building to sway back and forth about 12 inches." Beware of master streams.

Firefighters should consider the use of a master stream as a collapse danger. Master streams have saved the lives of many firefighters by allowing the incident commander an effective alternative to aggressive interior fire attack in vacant buildings. However, there is a danger if master streams are not used properly: they can injure firefighters with the powerful streams.

Repositioning Master Streams

The most serious collapse danger of a master stream, however, is caused by the large volume of water it discharges into a burning building. One gallon of water weighs a little over eight pounds. The average master stream delivers 500 gallons each minute. This is two tons of water, or 4,000 pounds, every minute coming out of the master stream. When a master stream has been operating for 10 minutes, it has discharged 20 tons, or 40,000 pounds of water weight, into the building; three master streams delivering water into a burning building will introduce 60 tons, or 120,000 pounds of water into the structure in 10 minutes.

Some of this water will be vaporized by the heat of combustion; most of it will flow through cracks, beneath doors, down the stairs, and back into the street. An undetermined quantity of water from the master stream will, however, be absorbed into plasterboard ceilings and walls, dried-out wooden floors, and the porous paper and cloth contents of the building. It is this absorbed water weight that can cause a collapse.

Water from master streams can also become trapped inside a watertight, sealed floor area and quickly build up to dangerous proportions—sometimes as high as windowsill level. At one fire, water from master stream accumulations was seen spilling over windowsills and running down the front of a fire building seconds before all interior floors suddenly collapsed. Firefighters operating on floors below the fire were buried in the collapse. Incident commanders order master streams into operation. However, they often have other duties at a fire that do not allow them to closely supervise the master stream use.

The officer in command of the firefighter using the stream is also responsible for the effectiveness of the master stream use. If a master stream is no longer extinguishing flames and is instead discharging tons of water into a burned-out building, the company officer should inform the fire commander that the stream is not being effectively used and recommend that it be shut down or repositioned. Firefighters directing a master stream should constantly remind themselves that the nozzle is pouring water into the building a rate of two to four tons of water per minute. When they extinguish the fire in one window, they should move the stream to another window, never directing it at smoke for long periods of time.

Stream Direction

Today, inexperienced firefighters often must operate master stream nozzles without the supervision of a company officer. Inexperienced firefighters who have used only small, handheld streams during their careers may not be aware of the difficulty of directing the powerful master stream.

This problem was explained to me at a conference one day. A battalion chief ordered a firefighter to direct a deck gun into a window of a tenement to protect people trapped by flames on a fire escape. The first attack hose line inside had suffered a burst length. Flames coming out a window prevented the people from descending the fire escape. The chief urgently ordered the pumper repositioned in front of the fire building and the booster tank water to supply the deck gun atop the truck. The booster tank had 500 gallons of water. This gives only about two minutes of deck gun use.

The order from the chief was to drive the flames back into the window below the people on the fire escape. When water came out of the nozzle, the firefighter, unfamiliar with the difficulty of maneuvering a large master stream, directed the water stream up the face of the wall, alongside the flaming window, across the top of the wall above the flaming window, then down the side of the wall, next to the flaming window. Then, the water supply ended. He completely missed the flaming window. Needless to say, the chief was upset. Fortunately, the interior hose stream extinguished the fire coming out the window, and the people were safely removed from the fire escape.

All firefighters should be trained in the control and direction of large-caliber aerial and ground stream nozzles. I used to wonder what was the purpose of the contest, held each year on Firefighters' Day, in which a tire is suspended in the air by a rope and fire companies take turns operating master streams to see which company can get the stream inside the tire for the longest time. Now I know.

Positioning Apparatus

When responding to an initial alarm for a structure fire, only one engine and one ladder should enter the street. All other apparatus should remain at the intersection to avoid apparatus congestion in front of a fire building. When they are needed, the chief should call them onto the block. During this so-called level I staging, the first-arriving ladder should take a position in front of the fire building so that the best use may be made of the aerial ladder or tower bucket for lifesaving rescue. Naturally, the ladder truck has to be positioned correctly for use of the ladder or bucket lifesaving rescue. However, if there is no immediate rescue need and there is a large fire on arrival, it is likely that an aerial master stream will be used.

If there is a danger of future wall collapse, the ladder truck should be placed outside the collapse zone at the start of the operation. At a multistory large mill fire or church fire, where a collapse zone would place the apparatus too far away from the burning building, the ladder driver should consider positioning the truck in a corner safe area. (The corner safe areas are at the four corners of a building.) If you could look at the burning building from a bird's-eye view and imagine all the four enclosing walls falling straight outward in a 90°-angle collapse, you would see that the four corner areas of the building have fewer bricks on the ground. At the corners there will be little collapse rubble. The law of probability states there is less chance that the ladder truck will be buried by a collapsing wall if the rig is parked in one of the four corner safe areas. The aerial platform stream tip could still be operated close to the fire building near the corner and have a stream directed into the front windows.

Reconnaissance

Firefighters operating streams elevated high above street level are usually the first to detect hazards such as water buildup on a floor or a roof. Firefighters in the bucket atop an aerial platform have a greater overall view of the fire scene than personnel working on the ground. They should immediately notify the incident commander of any water accumulation. Roofs surrounded by parapet walls on the four sides of the building are especially prone to water buildup. If drains are clogged and several ground-level master streams are operating, a roof area may fill up with water quickly and collapse on firefighters inside the building.

The hollow area inside a marquee or canopy attached to a building is another place where water accumulates. The weight of water buildup inside the void of a marquee whose drains are clogged can make the marquee collapse and also bring down the front facade wall to which it is fastened. When any of these dangerous conditions are discovered, notify the incident commander. Firefighter safety responsibility depends on teamwork, not on any one individual. The incident commander is expecting fire ground hazards to be reported to the command post. Remember, the incident commander cannot see inside the building; the incident commander cannot see the rear of the building, and the incident commander cannot see conditions on the roof. Firefighters and fire officers are the eyes and ears of the incident commander. Report what you see.

Wall Collapse

When a master stream is redirected from window to window on a burning masonry building, it strikes the brick wall between openings at close range. If the cement bonding between the finished stone or brick veneer and the back wall to which it is attached has lost its adhesive qualities over the years, the impact of the stream can cause large sections of stone or brick veneer to collapse into the street below. A master stream continuously directed at a brick wall or wood-shingle wall at close range can blast away the wall and throw fragments of the wall into the air. During a nighttime fire or where smoke reduces visibility in the street to zero, the incident commander must rely on the sounds of the master stream to determine its effectiveness. For example, when a master stream strikes a brick wall hidden in smoke, a “splattering” sound is made by the stream; when it strikes the side wall of a wood building, a “drumming” sound is made by the stream; when it enters a window, the sound of the master stream is reduced, and only a distant rumble is heard.

Strategy for a Collapse Zone

Some incident commanders utilize an unusual firefighting strategy when operating at major fires. When the wall of a building is in danger of collapse and all firefighters working at ground level are ordered to withdraw from the perimeter of the building and establish a collapse danger zone, sometimes the aerial platform is positioned within the same collapse danger zone by the chief. When an incident commander establishes a collapse zone for firefighters operating at ground level, in the street, it should be understood by sector officers and company officers that the same order applies to those operating aerial master streams in buckets.

This precaution is imperative because, in recent years, an increasing number of building collapses have killed or seriously injured firefighters operating aerial master streams in the bucket of aerial platforms. The tip of the aerial ladder or platform bucket should be kept away from a weakened wall, at a distance several feet more than the height of the wall above the aerial stream bucket floor. This additional distance is required because there will be a curve outward if a collapse occurs.

Master Stream Strategy during Overhauling

Overhauling is the most dangerous time of a fire. Collapse is a possibility because the building has been destroyed by flame, the impact of the master streams has pounded the building, and tons of water has been absorbed by the plasterboard, wood, and concrete of the structure. After long-duration use of a master stream has been completed and the main body of fire has been extinguished, the incident commander should order master streams shut down. The large-diameter streams used for total extinguishment have accomplished their task.

Now, before any firefighter is ordered to reenter the burned-out, smoldering, water-soaked structure to overhaul, the following safety actions should be taken: First, the building should be allowed to drain. Wait 10 minutes for the structure to settle and for some of the water to spill out. Next, the incident commander can conduct a survey of the building exterior walls. Then, send a safety officer and an assistant inside the burned-out building to evaluate the interior and conduct a safety survey.

The safety chief should determine if it is safe to allow firefighters to enter and overhaul. During this inspection, the safety chief looks for the following warning signs: broken stair treads; cracks in marble on intermediate stair landings; sagging of the floor and ceiling, owing to the weight of water; and fire damage that twists, warps, bends, and/or elongates steel columns and girders. The presence of trusses and/or lightweight steel bar joist or wood I beam construction must be reported to the incident commander. Water accumulation and heavy machinery are warning signs of floor failure. Water-absorbing content—such as paper bales, baled rags, or plumbing supplies—creates heavy loads that could cause collapse during overhauling.

If the safety officer decides that the structure is safe, the incident commander may start overhauling but limit the number of firefighters who reenter to extinguish spot fires. However, if the safety officer decides the structure is unsafe, no firefighter should reenter the structure. Instead, the incident commander should order *defensive overhauling*. Defensive overhauling is a strategy of directing a master stream or several hose lines from outside the burning building and outside the collapse zone into the burning structure for several hours or days if necessary. Firefighters may be rotated in or out of each tour. Defensive overhauling, also called a watch line, is continued for however long it takes until the smoldering fire is quenched.

An incident commander and firefighters must realize that even after all precautions have been taken, the building could still collapse and kill firefighters. Sometimes, a building will collapse after all possible safety precautions have been taken. There may be no warning signs, no time to act, and no satisfactory explanation of the tragedy. This is the nightmare of all chief officers. It is this fear that causes the incident commander to withdraw firefighters from inside a burning building.

Even though the burning building does not collapse at most fires after firefighters are withdrawn, this does not indicate that the incident commander's decision to switch from interior to exterior attack was incorrect. Rather, it indicates that the incident commander understands the priorities of firefighting. The priorities of firefighting are worth reiterating: life safety is the first priority, fire containment is the second priority, and property protection should be the last consideration of the incident commander during any fire or emergency.

27 FIRE AND EXPLOSIONS

A surprise explosion is part of a firefighter's deadly uncontrolled work environment. Explosions occur at fires, and there are ways to protect firefighters from explosions. An incident commander must have a firefighting plan of action to prevent or mitigate the effects of an explosion. Explosion, collapse, flashover, toxic gases, flames, superheat, and deadly smoke are all parts of firefighters' workplace. Each year, the effects of explosions injure and kill firefighters. These explosion effects are the blast, the ball of fire, the shock waves, the flying shrapnel and primary fragments, and the secondary fragments—a hurricane of flying glass, bricks, and wooden splinters from doors—and collapsing ceilings, partitions, and walls.

Definition of an Explosion

Fire protection engineers define an explosion as a sudden violent expansion of gases. Some deadly effects that accompany an explosion are shock waves of high pressure, fire and smoke eruptions, flying glass and container fragments, and collapsing partitions and walls. Searing heat, black clouds of smoke, balls of flame, and a loud noise are also produced by the sudden violent expansion blast called an explosion.

Fire protection engineers classify explosions into three broad categories: physical explosion; physical/chemical explosion; and chemical explosion. For example, a water heater boiler rupture would be a physical explosion; the container would rupture, but there would

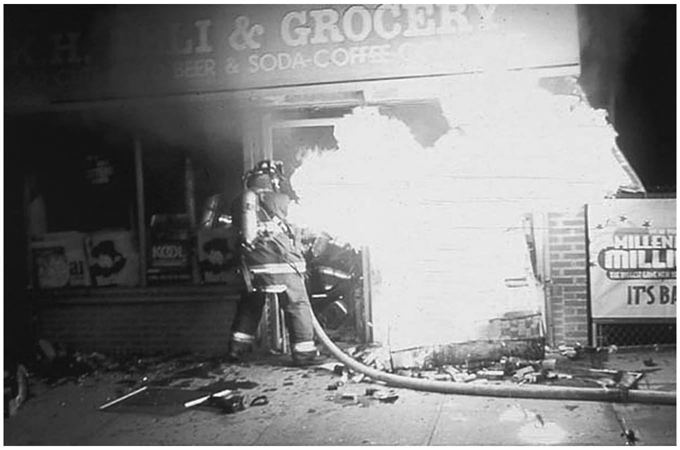

Fig. 27–1. A smoke explosion is a sudden violent expansion of fire gases.

be no ensuing explosion of the water. A propane cylinder BLEVE (boiling liquid expanding vapor explosion) would be a physical/chemical explosion; there would be a physical explosion—a rupture of the cylinder, then an instant chemical explosion of the flammable propane. A smoke (backdraft) explosion would be classified as a chemical explosion (fig. 27–1); the smoke and gas would react with oxygen and heat in a burning room.

The chemical reaction and explosive ingredients present in a smoke explosion (backdraft) are the same as in any ordinary combustion explosion: fuel, oxygen, and heat. The fuel in a combustion engine explosion driving an automobile is gasoline. The fuel in a gas explosion is methane gas, and the fuel in a smoke or backdraft explosion is smoke; the explosive smoke is carbon monoxide (CO). CO has an explosive range of 12–74% when mixed with air.

There are three important facts an incident commander should know about any type of explosion.

Explosive atmosphere

First, for an explosion to occur in a room or fire area, only 25% of its space needs to contain the explosive mixture. If the explosive mixture is in one corner of a large smoke-filled room, the entire area could explode when firefighters enter to search and allow fresh air to enter with them.

Effects of shock wave pressures

Another fact is that it does not take much explosive pressure in a confined space for an explosion to cause death and destruction. The higher the peak pressure developed by the explosion, the more deadly will be the blast. Following are the destructive effects caused by explosion pressures:

Effect of Explosion	Destructive Peak Pressure
Glass shattering	0–5 psi
Firefighter knockdown	1 psi
Wood partition collapse	1–2 psi
Cinder block wall collapse	2–3 psi
Brick wall collapse	7–8 psi
Firefighter lung damage	15 psi
Threshold for fatalities	35 psi
50% fatalities	50 psi
99% fatalities	65 psi

Elements of an explosion

The third fact that the incident commander should know is that there are several phases of an explosion. First is the original shock wave blast of the explosion; next is the flying shrapnel of the exploding container; then, depending on the pressures of the blast, parts of the enclosing building are carried along with the blast, such as walls, doors, windows, and suspended ceilings. A pressure vacuum in the street during a blast can implode parapets and windows into the street. For example, in the street, after a manhole explosion between buildings, when the shock waves of the blast rise between buildings, a vacuum and an implosion into the street can occur. This happens when, during the blast, the atmospheric pressure inside nearby buildings becomes greater than the atmospheric pressure in the street, and as a result, the glass from windows is blown out into the street, instead of into the apartments.

A final effect of an explosion can be secondary fires. After an explosion, ground shock waves may break gas, water, electric, and sewer pipes. Subway tunnels and building foundations are sometimes affected.

Reducing Injury and Death by Explosions

General warning signs

First, some explosions happen suddenly, and they are unpredictable. Explosions are a constant part of a firefighter's deadly uncontrolled work environment. However, warning signs of backdraft or smoke explosions may be detected by an incident commander, and precautions should be taken. Warning signs include reversal of air pulling smoke back into a smoke-filled doorway, black smoke pushing out around a closed door or window frames, and glass windows stained with smoke condensation and pulsating from the pressure of the fire.

Firefighting strategy

When fighting gas fires, the strategy is to shut off the supply. Firefighters must be trained not to extinguish a gas fire with a hose stream. They must be trained to let the gas fire burn and protect exposures from fire until the gas can be shut off.

Overhauling

After a fire is extinguished and before overhauling begins, the strategy is to have the gas and electric shut off. During a serious fire, gas pipe joints may fail and leak explosive gas, and a spark of electricity could cause a blast. When performing structural overhauling where walls and ceilings must be opened to examine for hidden fire spread, gas pipes and electric wires will be exposed. If the gas and electric supply to the building is shut off, this limits the danger of explosion due to leaking gas and electric spark ignition.

BLEVE

A BLEVE may occur during a fire near a burning propane cylinder. Incident commanders should order firefighters to cool the vapor space of the cylinder, shut off the gas by the control handle if possible, and if the flow of burning gas cannot be shut off, allow the propane gas to burn, after withdrawing to a safe distance.

Explosive investigation

After a fire has been extinguished and explosive or flammable liquid residue left by an arsonist is discovered in the burned-out rubble, the incident commander should order firefighters not to disturb the area—to withdraw, cease overhauling, and notify the fire investigators to respond. If an investigator determines that the blast was not the result of a broken gas pipe, a BLEVE, or the flammable vapor residue of an arsonist, then the incident commander can state that the cause of the explosion was a backdraft.

Occupancy-specific warning signs

Incident commanders should be able to identify the occupancies in which there is an associated risk of explosion. Explosion occurs in store occupancies more often than in residential occupancies. Store occupancies, unlike residence occupancies, are more likely to contain explosive and flammable solids, liquids, and gases. Paint stores, hardware stores, woodworking shops, motor vehicle garages, restaurant kitchens, construction shanties, flower and garden shops, stores under renovation, and buildings illegally storing propane cylinders are all occupancies with an elevated risk of explosion. Fire inspections should require that fire suppression systems be installed in these occupancies. Also, like truss construction, these dangerous occupancies should be subject to fire preplanning and notification of the first-responding firefighters; first-responding incident commanders should be notified of the explosion danger and the preplan when responding to that location (fig. 27–2).

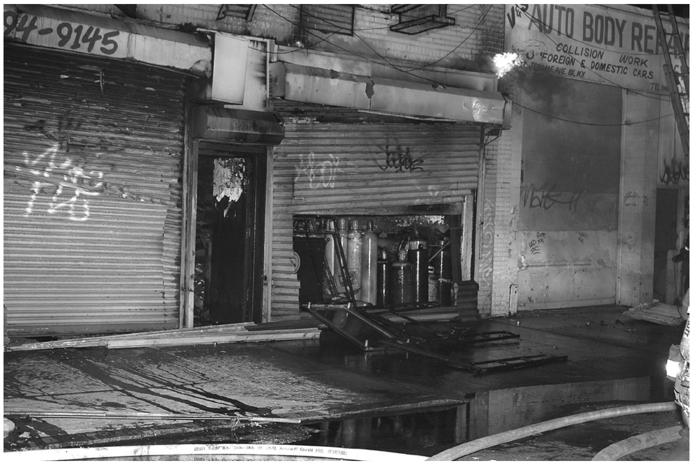
Fig. 27–2. Use a defensive exterior attack when fire involves compressed gas cylinders illegally stored in a building.

Manhole explosions

When a manhole cover is emitting smoke and popping off the street, firefighters stretch a hose and stand a safe distance away from that and other nearby manhole covers. There is a great chance that a violent explosion in the manhole will blow the heavy metal cover a hundred feet the air and shatter nearby windows. Incident commanders should direct drivers not to park fire apparatus in the street near other manhole covers. Nearby cellars are checked for fire and smoke spreading to or from the manhole through electric or gas conduits. The utility company is called to the scene, and firefighters await electric supply shut-off.

Car fire explosions

When extinguishing a vehicle fire, firefighters use the reach of a hose stream and stand away from fuel tanks and explosive bumpers.

Bomb discovery

When an explosive is found at the scene, the incident commander should order firefighters not to disturb the device. Firefighters should instead be directed to evacuate the people, withdraw to a safe area, notify the bomb squad, and stretch a hose line and prepare for an explosion, collapse, and fire.

Defensive actions

At an explosion, flying fragments such as glass, brick, and shards of splintered wood cause most injuries. Shrapnel should be foremost in the minds of firefighters operating at the scene of a potential explosion. The incident commander should instruct firefighters to place eye shields down and to use apparatus and buildings as a blast shield.

Protecting Firefighters

There are firefighting strategies that can reduce the effects of an explosion when operating at a fire. They are venting, quenching, flanking, and setting up a collapse zone.

Venting

Venting a roof skylight over a burning store is one of the most effective methods of protecting firefighters from the blast of an explosion. When roof conditions permit, the quick removal of a glass skylight by firefighters can vent a smoke-filled store and break up an explosive mixture. Even if the smoke explosion occurs, the blast will be diverted upward out of the roof vent opening, away from the firefighters advancing the hose line.

Quenching

Quenching the superheated confined fire area is another safety and survival tactic that firefighters can use to prevent explosions. Before a room or store is entered in which there is the danger of an explosion, a charged hose line should be positioned to the side of the entrance. Firefighters in full protective equipment should immediately discharge a hose stream into a fire area when it is opened up. This water may cool a potentially explosive atmosphere. Before searching firefighters enter a confined, potentially explosive fire area, the stream of a powerful water discharge can break up the explosive atmosphere. This is not as effective as roof venting, but sometimes it is the only alternative.

Flanking

When there can be no venting and quenching by a hose stream is not possible, firefighters can protect themselves from a low-peak-pressure explosion by flanking a doorway to a burning room while operating hose lines. Flanking a doorway with hose streams will protect firefighters only from low-pressure explosions. Some explosions create low blast pressures of 0.5 psi, which can break windows, to 1 psi, which can knock down a firefighter standing in an open doorway. A blast of 2–3 psi will collapse a wood partition. It takes a peak pressure of 7–8 psi to collapse an eight-inch thick wall.

When flanking a store, the officer in command can order two hose lines into position, one on each side of a doorway or window of a burning store, which is suspected may explode. After the hose lines are charged with water and firefighters are in full protective equipment, the front store glass door or window is vented by breaking from a safe distance. Both flanking hose lines, safely out of the path of any potential explosive blast coming through the opening, can be directed into the burning store.

Collapse zone

The perimeter of a burning building is a deadly area. A high peak pressure from an explosion can cause walls to collapse and fall outward, into the street. If an incident commander positions firefighters outside the collapse zone and away from the building wall, they will be protected from some of these hazards. A collapse zone for an explosion should be distance away from a wall equal to twice the height of the wall.

Admittedly, some of these strategies are half-measures. However, during a fire, when lives civilian lives are threatened, it may be all we can do. As incident commanders, to protect lives, we must direct firefighters to work inside and close to burning buildings. If we do not, more lives will be lost, and the fire will grow and spread to adjoining buildings and become even more dangerous to the community and firefighters. Actually, we would have more explosions if we did not aggressively fight fires and instead let the buildings burn. The incident commander must remember that explosion protection of last resort is a firefighter's full protective gear: helmets, eye shields, hoods, gloves, boots, bunker pants, coat, and face mask. Protective fire gear may be hot and cumbersome and may slow firefighters down, but if caught in an explosion, it may determine whether they survive the blast and if so, the seriousness of their injuries. Ensure that all firefighter wear protective clothing.

Backdraft Investigation

The traditional fire service theory of how a smoke (backdraft) explosion develops is as follows: A fire starts in a confined space. The fire grows (stage 1, the growth phase) undetected. Flames rise up to the underside of the room, then spread along the ceiling to the outer walls. Confined by the walls, smoke and heat start to descend in the room. The fire may flashover and go through the fully developed burning stage (stage 2) in a sealed-up room. As the smoke and heat fill the room and approach the floor, most of the oxygen is consumed. Now, the incomplete combustion process of the oxygen-starved fire (stage 3, the decay phase) starts, and carbon monoxide and other combustible gases are given off. As the fire continues to smolder, the burning room contains a mixture of heat, fuel (carbon monoxide), and insufficient oxygen. Only two of the three ingredients of the fire triangle now exist in the burning room—fuel and heat.

As the firefighters arrive, open up the room, and crawl into the smoke-filled room to search for the fire, they let fresh air into the room. The entrained air (oxygen) brought in by the firefighters may mix with the carbon monoxide (fuel) and burning embers (heat) and cause a smoke explosion (backdraft). Air triggers a smoke explosion. This explosion has combustible smoke as a fuel and burning embers and sparks from the room's furnishings as the heat source; the sudden gust of fresh air brought in by the searching firefighters provides the missing part of the fire triangle, oxygen.

This traditional theory of a smoke (backdraft) explosion leads to two

Fig. 27–3. A backdraft explosion occurred on the sixth floor of this building.

conclusions: first, the explosion occurs in the room of fire origin; and second, the fire is in the third stage of development, the decay stage. Scientists tell us that theories are models used to explain some unknown event. Theories allow us to communicate; however, theories are approximate and incomplete, and most important, theories change when new evidence is discovered.

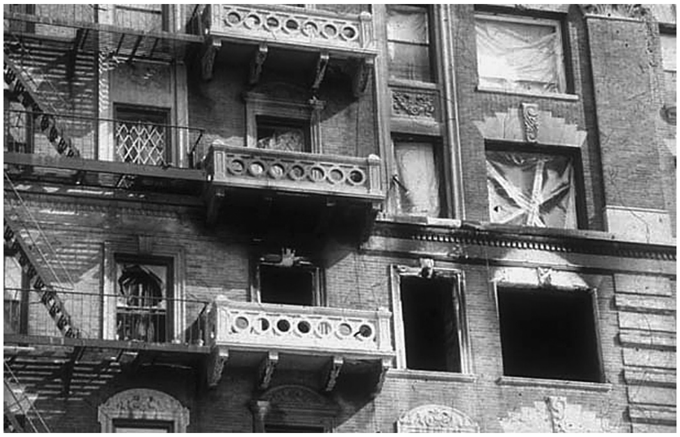

Fig. 27–4. This explosion blew out double windows on the floor above the fire.

Assistant Chief Frank Fellini and I conducted an investigation into a backdraft explosion that occurred in an apartment in a seven-story multiple-dwelling ordinary-constructed building, at Box 1514, at 129th Street and Lenox Avenue on June 12, 1990 (fig. 27–3). The findings of our investigation challenge the aforementioned two assumptions of the traditional theory of backdraft explosion: first, that backdraft explosions occur in the area of fire origin; and second, that the backdraft explosion occurs during the third stage (decay) of a fire. This investigation drew the following major conclusions: the backdraft explosion occurred in the apartment above the fire (fig. 27–4); and at the time of the blast, the fire was in the first stage of development, the growth stage, not the third stage. As a result of this investigation, firefighters should realize that backdraft explosions can occur in occupancies adjacent to the main fire and that the blast may occur when the fire in the adjoining occupancy is in the growth stage. This information is important for the safety of firefighters.

The chief in command said that an explosion suddenly blew out the entire window and metal frame from the apartment on the sixth floor, the floor above the fire, onto the street. The next morning, a postfire investigation was conducted of both apartments, with the following findings:

- This was definitely a smoke explosion. The fire in the fifth-floor area of fire origin was burning in stage 3, the decay stage, and it generated carbon monoxide, which served as fuel for the blast. The investigation found no leaking natural gas pipes or meter. This was not an arson fire. An elderly woman lived in the apartment, and the fire was declared accidental. There were no signs of a ruptured container or cylinder.
- The fire on the fifth floor burned undetected for several hours after the woman left to go to work. New double-paned thermal windows kept the heat, fire, and smoke in the tightly sealed apartment. The fire burned through stages 1 and 2. During stage 3, the decay stage, before the arrival of the fire department, the plasterboard ceiling burned away in the fifth-floor apartment, and flames burned the underside of the floor above, the

apartment on the sixth floor. During the fire, smoke under pressure took the path of least resistance to the apartment above and seeped through the burned floorboards. In the sixth-floor apartment and the room where the explosion occurred, traces of paint blistering on the molding of the doorway revealed the only signs of flame. This area of burning revealed the presence, just before the explosion, of a small pilot flame of smoke and heat coming from the fire apartment below. The fire in the apartment on the sixth floor, where the blast occurred, was just entering stage 1, while the apartment below was in stage 3. Carbon monoxide gas was pushing up from the fire burning on the fifth floor into the apartment on the sixth floor through the floorboards.

- At the time of the explosion, the sixth-floor apartment rooms were two-thirds full of smoke; the bottom third of the apartment was clear. As firefighters entered the smoke-filled apartment to search for reported trapped victims, they brought with them fresh air. When one firefighter passed the smoldering room, fresh air followed. Just then, a room in the apartment exploded. The double window and metal frame blew out into the street. One firefighter was burned around the mask face piece; the other shaken firefighter was rescued from a window.
- The fire originating in the tightly sealed fifth-floor apartment with new energy-efficient windows progressed from the growth stage through the fully developed stage to the decay stage. In the decay stage, the smoldering, or so-called incomplete combustion, generated carbon monoxide and other explosive gases. After the plasterboard ceiling of the fire apartment burned away and the floorboards above the missing ceiling were charred through, these combustible gases and heat were pushed upward into the sixth-floor apartment. After smoke filled the apartment above the fire, the pilot flame burned through the floor. In the sixth-floor apartment, two stages of the fire triangle existed; there was heat from the pilot flame, and there was fuel in the form of carbon monoxide gas. When the firefighters entered the apartment above the fire, they brought in fresh air, the third side of the fire triangle, and the apartment exploded.

Explosion Investigation

The fire service does not adequately investigate and document smoke (backdraft) explosions that occur during fires. We see it happen during fires; we talk about it in the firehouse; if we are lucky, someone photographs it. But that's it. Unless there is an injury or death, we do not investigate.

When we do investigate an explosion that occurs at a fire, we usually find it is not a smoke (backdraft) explosion. Most explosions at fires involve leaking natural gas, vapors from an arsonist's accelerant, or a BLEVE caused by the heating of a sealed propane container. For example, during a fire, an explosion results from the ignition of a natural gas pocket flowing from a broken gas meter; or there may be a reignition of flammable liquid vapors left over from an arsonist's spill; or a small propane tank or pressurized household spray may cause a BLEVE that appears to be a smoke explosion.

When any of these materials explode in a burning room, there is a blast of smoke and flames out a doorway or window; this blast looks identical to a smoke (backdraft) explosion.

Most explosions that occur at fires are not smoke (backdraft) explosions. The terms smoke explosion and backdraft explosion are incorrectly used to describe all types of explosions. Before we declare an explosion to be a smoke explosion, we must investigate the fire scene and rule out other possible causes of the explosion. We can eliminate the natural gas cause by checking the gas lines and gas meters in the building. Next, by using a hydrocarbon sniffer, we can eliminate an arsonist's flammable liquid as a cause if there is an absence of hydrocarbon vapor. Finally, we can eliminate propane tanks and BLEVE as a cause by an inspection of the fire area as long as we find no sign of a ruptured container. Only after an investigation and the elimination of these possible causes of explosion can we declare the blast to be a smoke explosion.

Backdraft explosions do not happen often. During my career, I experienced, up close, five such explosions. Three occurred in stores and could have been smoke explosions; the two others were container ruptures. I did not investigate any of the explosions; I was just glad no one was hurt. The blasts were not even mentioned in the fire reports. I erroneously assumed that explosions are just another part of the danger of firefighting.

Following is information about the explosions at my operations that were not investigated, from several perspectives:

- As a firefighter directing the initial attack hose stream in the doorway of a store. A blast of heat, flames, and smoke sent the company tumbling backward onto the sidewalk. I remember a shaken battalion chief running over to us, asking if everyone was all right. We did not see anything. He was amazed we were not seriously injured.
- As a company officer supervising the extinguishment of a pile of rubbish burning in a vacant building. A container exploded. The blast sprayed us with paint and pieces of the container.
- As a company officer waiting for water to supply our hose at a burning construction shanty. A nearby acetylene cylinder's fusible plug failed. The escaping acetylene gas suddenly exploded, blowing parts of the wooden shack into the air.
- As a chief officer arriving on the scene of a rapidly spreading fire in part of a row of stores. I saw a blast of smoke and flame blow back over a company operating a hose line in the doorway. The store that exploded was next to the main fire store. I was certain that there were several badly injured firefighters. I ran over to the firefighters and asked them if they were all right. They were. I remember that they looked at me as though I was overreacting. Then, I had a flashback of a similar event 20 years before. The firefighters did not see what had happened to them, but I did.
- As a chief officer directing operations at a rapidly spreading fire in a row of stores. An explosion blew out a large window in a check-cashing store. Again, this store was adjacent to the main fire occupancy.

Today, I believe that only one of the three smoke explosions could have been a true smoke explosion (the one

I experienced as a firefighter). The two store-fire blasts were probably caused by the residual vapors of an arsonist's accelerant. However, the important point about the other two explosions is that they occurred in stores that were adjacent to the main fire occupancy. The blasts did not occur in the store of fire origin, as the theory of backdraft explosion would suggest. Moreover, the fires in the stores where the explosions took place were in the first stage of fire development, the growth stage. The fires were not in stage 3 (decay), as the theory of backdraft explosion states.

As stated in the introduction to the traditional theory of a smoke explosion, I learned over the years studying for promotion is that a smoke (backdraft) explosion occurs in a tightly sealed room or area where the blaze originates. Also, the smoke (backdraft) explosion happens after the fire has progressed through stages 1 and 2 and is in the third, or decay, stage of fire development. I was taught that in the third stage of a fire's development, explosive carbon monoxide gas is generated. This was not what I saw in the explosions that I experienced up close. Furthermore, this was not what I found in the one explosion that I investigated. The fires in the two stores that exploded were in the initial growth stage, not the decay stage, and the stores where the explosions took place were not the stores of fire origin. They were adjacent to the main fire. Fire and smoke were spreading to the stores where the explosions took place.

28 COLLAPSE SIZE-UP

Firefighting safety is a team responsibility. Everyone at the scene must work toward the goal of fire ground safety and report collapse dangers. The incident commander must depend on sector officers, company officers, and firefighters inside and around the burning building to discover the collapse warning signs.

The strategy of detecting a collapse danger is as follows: When firefighters or fire officers discover a collapse danger, they must take necessary safety precautions in their area of command and then notify command of the collapse danger. For example, if a firefighter sees a danger, he reports it to his or her officer. The company officer evaluates the danger, decides whether it is real, and if it is, takes the necessary action to safeguard all firefighters in the area. The officer then notifies the sector officer (if there is a sector assigned) of the danger and safety actions taken. The sector officer also evaluates the danger and action taken and decides if the action taken by the company officer is sufficient; if not, the sector officer must take additional safety precautions and safeguard other companies operating in the sector area. After everyone is safe, the sector officer notifies the incident commander of the danger and also the action taken to safeguard companies working in the sector.

Sector officers, company officers, and firefighters are the eyes and ears of the incident commander when it comes to detecting a collapse warning sign. All firefighters must be trained to recognize collapse warning signs. Only after being notified of a collapse warning sign from a fire officer at the scene can the incident commander direct precautionary actions.

Collapse Warning Signs

There are several common warning signs that a burning building is about to collapse. Sector officers, company officers, and firefighters should look for the following:

- A cracked wall may signal that a wall collapse is about to happen. Cracks or loose mortar can be seen by smoke pushing through the masonry. This warning sign should be monitored continuously. If the crack in the wall increases in size, a collapse zone should be established (fig. 28–1).

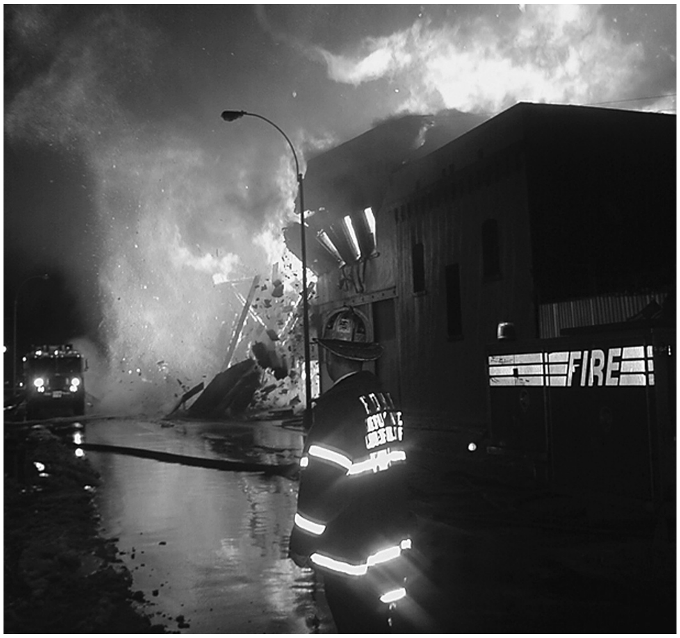
Fig. 28–1. A front wall was identified as a collapse danger, and all firefighters were withdrawn to safety.

During a fire, if structural steel beam or girder expands due to heat, it may cause a wall to crack and a possible collapse.

- Parapet walls, often found on the front of one-story commercial buildings in downtown shopping centers, are unstable structures. The parapet wall is the portion of an exterior wall that extends above a roof line. The presence of a leaning or cracked parapet wall must be considered a potential collapse danger. These walls often rest on top of horizontal steel I beams, connected to the roof only by metal tie-rods. The parapet wall may shift and crack when the heat from a fire warps the steel I beam or causes the roof to sag. The parapet wall could suddenly fall to the sidewalk, killing firefighters.
- A truss roof or truss floor in a burning building presents a sudden, early danger to the firefighters. The key to safe operations at a building with truss construction is early identification of the truss.
- When a firefighter discovers any type of truss construction, the officer in command must be notified (fig. 28–2). Only when an incident commander is aware of the presence of a truss can safety actions be ordered. When a fire involves a concealed ceiling space that contains a two-inch-by-four-inch lightweight wood parallel chord truss system or a steel bar truss, collapse can occur in 5–10 minutes Any burning structure with truss construction must be considered a collapse warning sign.

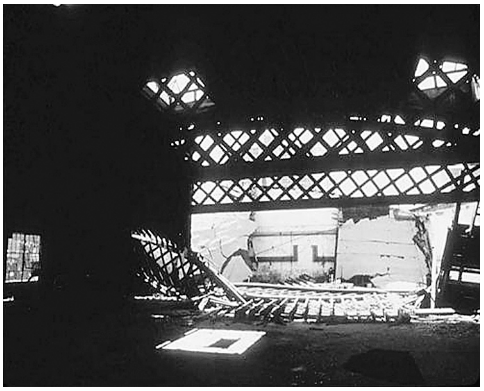
Fig. 28–2. The key to safe operations at a truss roof building is early identification of the truss and prompt notification of the incident commander.

- Cast-iron columns are an old collapse danger. New firefighters may not be aware of its collapse potential during a fire. Cast iron was used for

19th century factory and warehouse building columns and facades. When cast iron collapses, it shatters and the floor suddenly fails. There are no warning signs except for the presence of unprotected cast iron. Thus, the presence of this structural material in a building must be considered a collapse danger. When cast iron is used as a column, it is a key element in the structural frame. A column is a primary structural member. The definition of a primary structural member is a structure that supports another structural member. When a primary structural member fails, it causes the collapse of other structural members. When a cast-iron column fails, the floor and the entire building may collapse. Cast iron is also used as the decorative front of a building. When the cast iron of the facade fails, the entire building front can collapse into the street, burying firefighters operating hose streams. There are two theories of why cast iron fails during fires. One theory is that cold water from a hose stream can cause a heated cast-iron column to fail. Cast iron can be described as a brittle metal. If a burning building starts to shift during a fire, the cast iron cannot bend or flex. The cast iron breaks and collapses. When it fails, it shatters. Another theory states that a structural defect in the cast-iron column can cause other collapse problems. At one cast-iron column collapse, it was discovered that the columns were unevenly cast; the round columns had a thinner iron dimension on one side than the other.

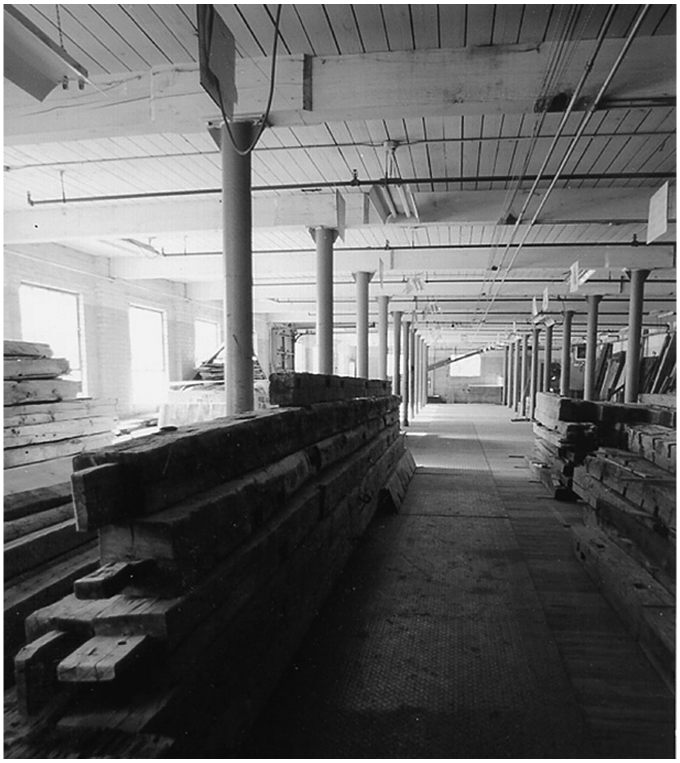

Fig. 28–3. Heavy floor loads and cast-iron columns are collapse warning signs.

- Regardless of the defect, unprotected cast iron must be considered a collapse danger, and the officer in command must be notified of its use inside a building (fig. 28–3). When cast iron collapses, it fails suddenly, usually causing other parts of the structure to fail and the deaths of firefighters.
- Water accumulation is a collapse warning sign. A heavy-caliber stream discharging 750 gallons of water per

minute into a burning building delivers three tons of water every minute (one gallon of water weighs 8.3 pounds). The buildup of water weight on roofs or floors of a burning building have caused a building to collapse. The use of several master streams at a fire must be considered a collapse danger (fig. 28–4). The impact of the master streams and the addition of the water weight may weaken the burning structure. There does not need to be water buildup in the building for it to collapse. Tons of water may be absorbed into the old dried-out plaster or wood, increasing the load in the burning building.

- Baled rags, paper, and cardboard boxes and bolts of cloth may also absorb water from streams and exceed the building's designed floor load capacity. This material may also expand as it absorbs and pushes out a wall, or the increased weight of absorbed water could collapse floors. When using master streams in a burning building that contains baled storage goods, prepare for a collapse.
- A bulging wall of a wood frame building, particularly one that has a fire escape attached to it, is a collapse warning sign. The cantilever load created by the fire escape could be causing the unstable wall. The bulge could be caused by the deterioration of the mortise and tendon connections fastening the four walls together.
- Another warning sign in a wood frame building is the cracking of a building wall at the corner. This could mean that the walls are coming apart. Another serious collapse danger sign of a wood frame building is tilting or leaning slightly to one side. This leanover signals that the building could fall over on its side. This warning sign justifies an exterior operation. Another collapse danger sign of a burning wood frame building is heavy fire on the first floor. The first floor bearing walls of a multistory building support most of the structure's load. When the first-floor bearing walls are burning, there is more of a chance of collapse than when the upper-floor bearing walls are burning.
- Certain heavy content of a building can cause a building failure during a fire. Storage occupancies—such as plumbing supply houses, furniture warehouses, machine shops, printing plants, rag and paper storage buildings, and occupancies containing heavy factory machinery—have been known to suffer collapses during fires. Some renovated

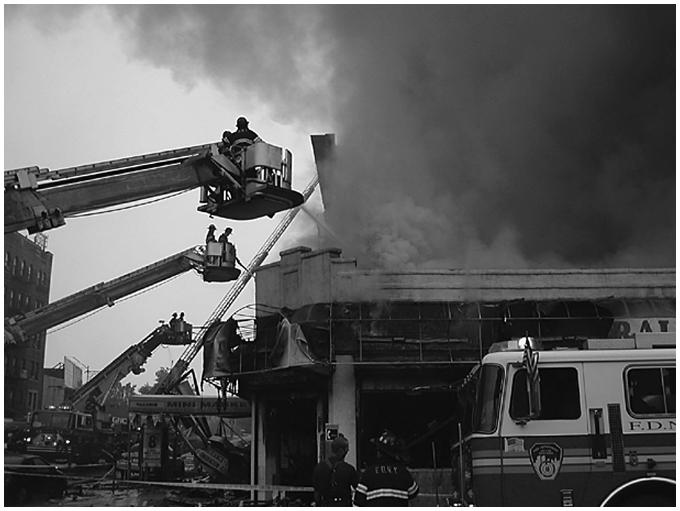

Fig. 28–4. Three master streams each delivering 5 tons of water per minute send 150 tons of water into a building in 10 minutes.

buildings undergo a change in occupancy; the structure may have been designed as a residence and is now used for manufacturing. Consequently, the floor may not be reinforced to support heavy machinery. All of these occupancies and any known renovated or change-of-occupancy building can be a collapse danger. When any such contents or changes are discovered during an interior fire operation, they should be immediately reported to the incident commander.

Once again, the key to a safe operation in a burning building with any of these collapse dangers is early identification. Any fire officer or firefighter discovering any collapse warning sign should immediately notify the incident commander.

Strategy for Collapse Safety

The incident commander must have a strategy to safeguard firefighters at the scene after a collapse danger has been reported to the command post. The following are several collapse safety strategies that an incident commander can use after a collapse danger has been identified.

Once notified of the collapse danger, the incident commander must order lifesaving precautions be taken. This could vary from the simple action of notifying all other sectors of the danger reported. Alternatively, the incident commander may take the most drastic action possible, which is ordering an emergency withdrawal of firefighters from the entire burning building.

The following are strategies for collapse safety that an incident commander may implement when notified of any collapse warning sign(s), in order of increasing severity: The incident commander may simply acknowledge the report of collapse danger for future consideration, or the incident commander may assign an officer to investigate the danger. If the danger is confirmed and operations must continue, the incident commander may increase supervision in the danger area and continue the operation. Also, safety equipment may be sent to the danger area for use. For example, set up lighting to more fully reveal the danger area; alternatively, position a surveyor's telescope, called a transit, nearby, and have a firefighter look through the telescope from a distance and monitor the collapse danger. A transit can detect a building's shift or the widening of a crack that is not visible to the human eye. Another action that could be taken is that the incident commander could have the danger area roped off or order a collapse danger zone be established, from which all firefighters would be withdrawn.

If the danger is great enough, the incident commander could order a partial withdrawal of firefighters from the dangerous section of the burning building. The incident commander could give a more drastic order and have a complete withdrawal of all firefighters from the entire burning building.

The most extreme action that an incident commander can take when notified of a collapse danger is to order an emergency withdrawal. The emergency withdrawal is more urgent than the normal order to back out of a burning building that is usually issued when changing strategy from interior to exterior operations. When an order is given for emergency evacuation, the danger is imminent, and speed of withdrawal is the primary aim. All heavy tools and hose are left behind during an emergency evacuation. This is not the case during a complete withdrawal owing to an increase in fire beyond the control of the forces on hand. For an emergency withdrawal to be carried out, there must be a prearranged emergency signal known by all members of the department. An emergency withdrawal signal may be long-term use of all apparatus: air horns or a portable radio frequency tone. When the emergency withdrawal signal is sounded, all firefighters must be trained to immediately exit the burning building and leave heavy tools and hose behind.

Managing the Danger Scene

Discovering and reporting a collapse warning sign is just part of the total safety picture. After the collapse danger is identified and safety actions have been ordered by the incident commander, the danger scene must be controlled. This is the hardest part of the incident commander's lifesaving actions. This was confirmed at a conference at which a chief relayed a story about the difficulties of managing and controlling a fire scene after the building had burned and partially collapsed. He relayed the following story:

Firefighters responded to an old five-story ordinary-constructed tenement building in a high-rent, high-value district of Midtown Manhattan. There were stores on the first floor and apartments for low- and medium-income residents on the upper floors. Fire started in the cellar.

On arrival fire companies stretched two attack hose lines to the cellar. The cellar storage area was overloaded with stock. Boxes were stacked up to the ceiling, with limited access throughout the cellar by way of narrow aisles. Piles of cartons were collapsing in the aisles, blocking the firefighters' future withdrawal. Smoke was building up in the below-grade area. The reach of the hose streams was blocked by the boxes at the underside of the ceiling. Piled stock should have a three-foot space between the stock and the underside of the ceiling for hose streams to reach a fire. Eventually, flames entered the ceiling concealed space and spread upward throughout the walls of the building.

The incident commander withdrew the firefighters from the cellar and changed to a defensive strategy. Outside aerial master streams were used to control the blaze. Fire spread to the upper floors, but it was confined to the one structure of origin. Adjoining, buildings on exposures 2 and 4 were searched, evacuated, and protected with interior hose lines.

During the day-long defensive outside attack using master streams, the floors collapsed. The front brick wall held. However, the front wall looked like it could collapse next. The incident commander assessing the building's stability saw that this century-old structure's wall had several collapse warning signs. In addition to the interior floor collapse, which created an outward pressure on the wall, there was a mansard roof. This indicated that the building was over a century old, since not too many residential buildings left in Midtown Manhattan have mansard roofs. (A mansard roof is a roof with two slopes on each of four sides; the lower slope is the steeper slope. The lower, sloping roof rafters of a mansard wall acts as the sloping hip rafters of a bowstring truss roof. The roof rafters can push out the wall if the roof collapses.) The building was very old and not maintained very well. The front brick wall had several cracks; there were metal plates holding the wall to the floors; a rusted old fire escape hung on the front of the structure. Also, there were large display show windows on the second floor. Incident commanders know the more openings there are in a wall and the greater the size of the openings in a wall are, the weaker the wall will be.

This fire was reported to the fire department at 1000 hours. It burned for seven hours and was declared under control at 1700 hours. No firefighters were injured. This was a successful firefighting operation in a dangerous building.

At the change of tour, the chief arrived on the scene. He was briefed by the incident commander and assumed command of the watch line that had been set up. No firefighters remained in the building overhauling; hydraulic overhauling was the strategy being used. An aerial master stream was wetting down the still smoldering building, pouring tons of water—going from window to window, floor to floor, for hours.

In light of this strategy, the chief enlarged the danger zone around the building, because it could collapse. Police barricades were moved farther from the burned-out building, enlarging the collapse danger zone.

The chief had identified the potential collapse danger. As he said later to me, "Identifying the collapse potential and setting up safety zones was only the beginning. That was the easy part." He knew that many deadly building collapses occur in the third and final stage of a fire, like this mop-up operation.

The Hotel Vendome in Boston was the most famous collapse that occurred in the overhauling stage. Nine firefighters died. In New York City, on October 2, 1962, six FDNY firefighters were killed beneath a collapsing metal canopy during the overhauling stage of a fire. There are three stages of a fire: the growth stage; the fully involved, flaming stage; and the decay stage. My friend the chief knew the third stage of a fire, the decay stage, is the period when many buildings collapse. At this stage of the fire, the burning building has been destroyed by fire, has been pounded by master streams, and has soaked up tons of water. Now it can collapse.

Maintenance of Safety Measures

The next several hours were spent conducting hydraulic overhauling with an aerial master stream and supervising the fire ground. The chief had his hands full, trying to manage the scene, and ensuring no one got too close to the obviously unstable front wall of the building in case it collapsed.

First, the housing people showed up. They said the building was sound, and it would be rebuilt. They wanted to enter and inspect. This building was under city and state government jurisdiction because it housed low- and middle-income residents. The official said it could not be demolished. It was required by law to be renovated and reinhabited by low- and middle-income residents of New York City.

My friend said, "This is still a fire scene, and I have declared the building unsafe. After we leave the scene, you can do as you wish. But until then you cannot enter."

Next, a fire company arrived at the change of tour, moved the wooden barricade, and started to drive the ladder truck into the collapse danger zone to get a closer approach with a tower ladder hose stream. The chief told them, "Back the ladder away from the building. Set up behind the police barricades."

Then, firefighters who worked the fire that day came back. They wanted to enter and look for missing tools. They were turned back and told to submit a lost-property report.

Con Edison's utility people arrived and asked to shut off the utilities inside the building. "Sorry, that will have to wait," said the chief.

Later, fire marshals showed up and tried to enter and investigate the cause. The chief informed them, "Do not enter the building. Tell your supervisor it's by my orders."

Finally, a television news crew wanted to film a close-up of the burned-out building for the 11 o'clock news. The advice they received from the chief was, "No good. Stay away. Use the telescopic lenses."

Collapse

At 8:30 p.m. that night, without warning, three hours after the fire had been extinguished and declared under control, the entire building suddenly collapsed into the street. The walls, floors, mansard roof, and metal fire escapes crashed down. Everyone was safely behind the barricades. There were no firefighter deaths or injuries.

The best strategy when there is the danger of a building collapse is to identify the danger and notify the incident commander. Then the incident commander must take action and manage the scene to ensure safety. However, the real lesson learned at the fire described above was that it's easy to identify a collapse danger, and it's even easier to establish or manage the scene after the collapse risk has been identified. However, it is much more difficult to control the scene and maintain the safety measures after they have been established.

Interestingly, the person who owned the building was at the scene that night when it suddenly collapsed. Immediately after he saw the building crash down into the street, he jumped up, shouted with joy and clapped his hands. Later, my friend asked why he was so happy to see his own building collapse into a pile of rubble, to which he received the following reply: "I own the land and the building; however, the building was under city and state control. The rents I could charge were limited by law. As long as the four walls remained, the government could renovate it. Once the building collapsed, they lost their jurisdiction over it. I now have property in this extremely high-value area of Midtown Manhattan. I have become a very wealthy person because of that collapse.

29 COLLAPSE SEARCH AND RESCUE

It is extremely difficult to control and organize a rescue effort at a sudden collapse. This is true if the collapse occurs during a fire operation or in response to a collapse disaster. There will be a large number of rescuers on the scene, rushing to the collapse area to dig out buried victims. The search for victims can be ineffective when it is done without knowledge of where the victims are buried. In fact, without coordination or a plan of action, the rescue efforts could cause further injury or death (fig. 29–1).

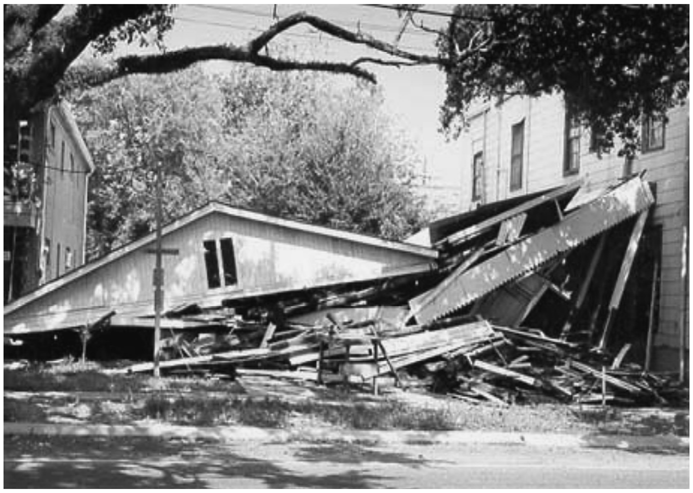

Fig. 29–1. There must be a collapse search-and-rescue plan when operating at a building collapse.

The strategy of detecting a collapse danger is as follows: When firefighters or fire officers discover a collapse danger, they must take necessary safety precautions in their area of command and then notify command of the collapse danger. For example, if a firefighter sees a danger, he reports it to his or her officer. The company officer evaluates the danger, decides whether it is real, and if it is, takes the necessary action to safeguard all firefighters in the area. The officer then notifies the sector officer (if there is a sector assigned) of the danger and safety actions taken. The sector officer also evaluates the danger and action taken and decides if the action taken by the company officer is sufficient; if not, the sector officer must take additional safety precautions and safeguard other companies operating in the sector area. After everyone is safe, the sector officer notifies the incident commander of the danger and also the action taken to safeguard companies working in the sector.

Even when the exact location of the victims is known, the fewer people engaged in actual rescue work, the better. It is quality of effort, not quantity, that is needed at a collapse search-and-rescue operation. One of the first actions that the incident commander must take is to control the scene. This may require that police secure the area and remove people from the scene.

A strategy for the overall collapse search-and-rescue operation is as follows:

1. Secure the collapse area;
2. If firefighters are victims, order a roll call of members at the scene;
3. Summon additional chief officers or company officers to increase supervision and to set up sectors;
4. Establish an incident management system;
5. Implement a collapse rescue plan;
6. Designate a victim-tracking officer to determine and record the exact number of people missing at hospitals as opposed to safe at home.

Securing the Collapse Area

The police department should be directed to secure the collapse area as soon as possible (fig. 29–2). Barricades or fencing should be set up around the entire collapse site. The access areas leading in and out of the collapse site should be guarded by police. People should be escorted out of the secured collapse area, and no one except fire, police, medical, and authorized construction workers should be allowed the enter the collapse operation zone. This action is critical for maintaining control of the collapse site. Streets within the collapse site area must be kept open to move heavy equipment belonging to the fire department and construction companies.

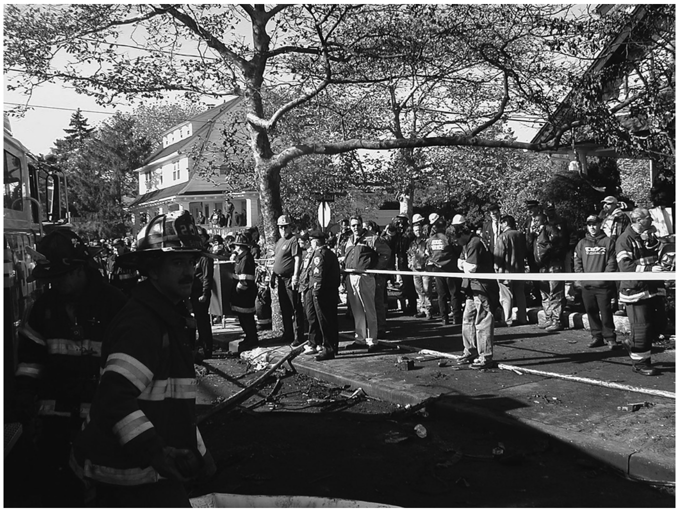
Fig. 29–2. The first step of a collapse search-and-rescue plan is to secure the collapse area.

Two recent examples, one good and one bad, show the importance of immediately securing the area of a collapse rescue operation. They are the Oklahoma City terrorist bombing and the World Trade Center terrorist plane attack. At the Oklahoma City building collapse, the fire department was quickly able to secure the area around the collapse site. In New York City, the fire department lost control of the collapse site.

The Oklahoma City collapse site was initially out of control, as there was an initial rush of townspeople into the collapsed building to rescue people. Everyone in nearby stores and offices wanted to help. Very shortly, there was an erroneous report that spread throughout the crowd of rescuers that a second bomb was about to explode. All the townspeople left the collapse site. During this retreat, the fire and police departments were able to get control of the area around the collapse and lock down the site. The area was secured with barricades and fencing. No one was allowed back in the vicinity of the collapsed building for 16 days. Only the FBI, police, fire, and construction personnel were inside the collapse rescue zone.

Unlike Oklahoma City, the 16-acre collapse site of the World Trade Center was very large, and because of the enormity of the devastation and loss of life, it was impossible to secure the large area for several days. The FDNY temporarily lost control of the scene. Freelancing media companies, firefighters, police, medical personnel, first aid workers, sightseers, politicians, and construction workers from all over the country flooded the collapse site, most wanting to help.

Securing the area around a collapse site is one of the most important steps of a collapse search-and-rescue operation. In addition to assisting the fire service in their rescue operations, it provides safety to citizens. The collapse site is hazardous for any person not wearing protective equipment. At the Oklahoma City collapse site, Rebecca Anderson, a nurse helping the fire department remove surface victims from the collapse rubble, was struck and killed by an object falling from an upper floor. This death occurred during the initial rush of townspeople into the collapse site. The collapse site was secured after this tragedy.

Ordering a Roll Call

At the New York City Waldbaum's Supermarket truss roof collapse in 1978, the incident commander, taking command shortly after the collapse and being informed of missing firefighters, gained control of the scene by issuing the following orders:

- Over the portable radio, an announcement was made to all units. They were ordered to withdraw from the building, conduct a roll call, and await orders.
- All the chiefs' drivers at the scene (firefighters/administrators) were ordered to supervise a roll call of personnel at the scene by contacting all officers and recording their account of all assigned personnel at the scene.
- Four sector chiefs were each assigned command of an exposure (A, B, C, or D). They were ordered to set up tower ladders and exterior streams at each side of the building to lessen intensity of the fire and ready a hand line to move in with a search-and-rescue team.

Summoning Additional Sector Chiefs/Officers to the Scene

As the previous actions show, additional supervisors are necessary at a collapse rescue operation. They are needed to fulfill the incident management command functions, to supervise critical exposure sectors, and to perform additional command duties, such as directing fire extinguishment, setting up the master stream, and launching search and rescue for trapped victims.

Establishing a Collapse Rescue Incident Management System

At a collapse rescue operation, command and control may be improved as follows: First, an operations officer should supervise the initial collapse search-and-rescue operations close to the collapse site. A logistics officer should be directed to assess the needs and call for heavy equipment such as cranes, bulldozers, and dump trucks. A planning officer should be assigned to work with the operations officer and command. Most important, there should be a designated victim-tracking officer to determine the number and the possible location of missing victims. A finance officer should start documenting outside contractors and mutual aid services called to the scene for future cost accounting. A public information officer should be on the scene to handle the crush of news reporters asking for information. A safety officer should be assigned to work with operations, and a liaison officer will be needed as other local state and federal agencies arrive.

Implementing a Collapse Rescue Plan

A collapse search-and-rescue plan should be put into action by the officer in command of the operation. There are eight steps to the collapse rescue plan:

1. Secure the area.
2. Survey the site of collapse.
3. Shut off all utilities, such as gas, electric, and water.
4. Search for and remove surface victims.
5. Search all voids and spaces created by the collapse structure.
6. Take a time-out! Withdraw all rescuers. At this time, after surface victim removal and void search have been completed, 75% of the survivors will have been removed from the rubble, and now the cost-benefit ratio starts to work against the rescuers. The dangers to rescuers become greater than the likelihood of finding victims alive. Safety has to be beefed up before rescuers return to digging and searching. Therefore, conduct a safety survey, ensure that utilities are shut off, and shore up unstable structures.
7. Commence selected-debris removal by hand-digging trenches and tunnels to areas where people were last seen before or during the collapse.
8. Start general-debris removal to clear the entire collapse rubble. The steps of a collapse rescue plan may be performed together if sufficient resources are available. One step of the collapse rescue plan need not be completely ended before the next step begins. However, the steps should be the strategy progression of the collapse search-and-rescue operation over the duration of the operation—hours, days, or weeks.

Conditions on Arrival at a Collapse

When a sudden collapse occurs, many firefighters will rush into the wreckage to search for and remove surface victims. Rescue of surface victims is step 4 of the collapse rescue plan. However, steps 1–3 (securing the area, conducting a safety survey, utility shut-off) will not yet have been accomplished. Therefore, the incident commander must consider giving specific assignments to police and incoming units to perform the first three steps of the collapse rescue plan. The safety survey (fig. 29–3) and the utility shut-off will be overlooked by firefighters rushing to rescue their trapped comrades, especially if there are cries for help.

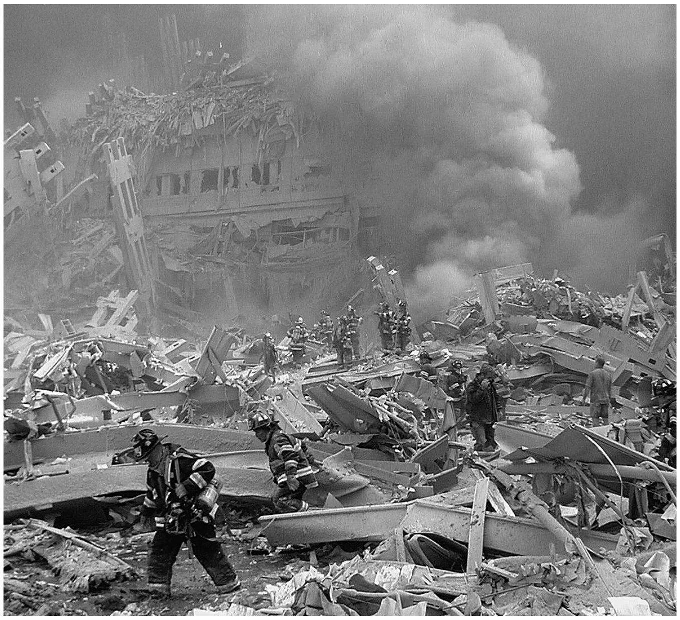

Fig. 29–3. The second step of a collapse search-and-rescue plan is to survey the area.

One of the most important safety assignments given by the incident commander at a building collapse site is to shut off building services such as gas, electric, and water. The local utility companies must be called to the scene, but before they arrive, firefighters should be assigned to shut down utilities. Utility companies are often delayed at night or on weekends. Utility shut-off is critically important because a broken gas pipe, leaking flammable gas throughout the collapse wreckage, can ignite and cause a severe explosion and secondary collapse, killing rescuers. Leaking gas could also accumulate in a concealed space where a victim is trapped and displace life-giving oxygen. If electric power is not shut off, live electric wires threaded throughout the collapse rubble may ignite gas or electrocute trapped victims and rescuers. Modern buildings are a maze of electrical wiring. If a rescuer gets a metal tool entangled with the live wire, he or she could be slowly and quietly electrocuted, unknown to other rescuers around him.

Water is another utility that must be controlled during a collapse rescue. Firefighters trapped below grade will often be the last to be rescued. Broken water pipes or long use of master streams may cause water accumulation in below-grade areas. Water from hose streams is often needed to keep flames from trapped firefighters; however, long-term use of water must be considered a danger to trapped victims. Water supply to the building must be shut off. Water removal operations may have to be started at a collapse.

Secondary Collapse

After a structural collapse in which portions of the building remain broken but upright, there is a danger of secondary collapse. A masonry wall may be cracked and leaning over the area where people are trapped, or a partially collapsed roof, unsupported at one end, may be hanging above rescuers. A second collapse could kill more rescuers than the number of firefighters originally trapped or buried.

The risk of a secondary collapse increases as firefighters work and move about the fallen building. They will cause vibration of the remaining structure. Moreover, mechanical removal of structural elements from the wreckage may prompt a secondary collapse. At an extensive collapse where prolonged rescue operations are to be conducted, a firefighter should be ordered to use a surveyor's transit to monitor unstable walls and floor. The transit is a surveyor's tool that has a magnified telescope that can rotate vertically and horizontally and can be sighted on a crack in an unstable wall. The transit can see movement not visible to the human eye from a safe distance.

If the crack widens or enlarges, the change can be detected through the transit telescope. The firefighter manning the transit should continually monitor the structure of an unstable building and report back the need for shoring or removal of the unstable structure.

Shoring

Emergency shoring may be used at a collapse site. Shoring may consist of portable jacks or cut timbers placed beneath an unsupported lean-to roof or bracing an unstable wall. Rope may be used to secure the end of an unsupported roof beam to a higher stable structure. The important point when shoring is not to move or attempt to restore the unstable structure to its original position. This movement could cause a collapse. If the supporting object or shoring is gently placed beneath the unstable structure, barely in contact with it, as the rescue work proceeds, movement of the building will tighten the point of connection at the shoring. When shoring is placed at an unstable structure, an observer, with a surveyor's transit, should be positioned at that point to monitor the structural member continuously. This observer should notify the incident commander of any further movement that might endanger workers below. If the wall leans out farther or the unsupported floor appears to move, rescue work must be stopped in the area, and additional shoring or removal must be undertaken.

Accountability

When a collapse occurs during a fire, the first duty of the incident commander is to determine who is trapped or missing. There must be an accountability roll call.

The company officer should have a record of all the firefighters riding on the apparatus. A firefighter's name on a handheld computer, or a paper riding list, or a plastic tag firefighter should be kept with the officer and on the apparatus in case the officer is one of the missing. After a collapse, this accountability system recording the names of responding firefighters must be checked during a roll call. The officer of every fire company must know how many firefighters are responding on the apparatus and must be able to identify by full name any member of his company who is reported missing.

Support Personnel

A rescue team engaged in victim removal requires that supporting firefighters supply rescue material and rescue equipment to them. Just as a doctor requires a team of assistants during an operation, so does a rescue team in the process of removing buried victims require cooperation and help from other firefighters. Instead of rushing in as a mob to dig out surface victims, some firefighters should act as support personnel, bringing needed tools, lumber for shoring, lights, and first aid equipment from a collapse rescue support vehicle to the collapse site. All available rescue tools must be brought to the vicinity of the rescue. At night, portable lights must be set up and supplied with a power source. Someone must be ready to cut timbers to any size requested when these are needed for shoring.

Rescue tools such as air search cameras, sound-sensing device to detect cries of buried victims, transit telescope, thermal-imaging cameras, inflation bags, portable jacks, and spreading bars must be made available at the scene. Medical personnel must have first aid equipment ready beforehand to stabilize victims discovered buried in the rubble. Stretchers, resuscitators, and bandages will be required. The support team should have all of these essential items and bring them to the rescue site. Behind every successful rescue operation are many unheralded firefighters who supplied the rescue team with everything they need.

Resources

Immediately after a collapse during a fire at which firefighters are trapped and rescue is required, the officer in command must summon additional help. Additional fire companies must also be called to continue the fire extinguishment effort. Many at a collapse site will engage in rescue, and firefighting efforts will suffer, causing the fire to increase. If the fire was not under control at the time of the structural failure and there is a possibility of its spread to surrounding buildings, a number of mutual aid fire companies equal to the number at the scene prior to the collapse may have to be called to continue fire extinguishment. After a collapse where firefighters are trapped or missing, the fire necessarily becomes a secondary consideration, so it usually increases in size and spreads to adjoining buildings unless firefighting reinforcements are quickly called. There should be an incident commander assigned to the rescue operation and an incident commander assigned to the firefighting operation, both working under an overall commander at the scene. The standard collapse rescue plan should be followed when firefighters are trapped in a collapse. Initially, a site survey of the remaining structure should be made if possible. Make a 360° survey of the collapse and look for secondary collapse dangers, trapped victims, fire spread, and avenues of access to the collapsed structure that might be used during the tunneling stage.

Utility Shut-off, Surface Rescue, and Debris Removal

The condition of gas, electric, and water services should be determined and rendered safe by shutting them off. While the reconnaissance survey and the utility shut-off are being carried out, most of the firefighters will have already rushed to the collapse area and will be searching for trapped firefighters. During surface victim rescue, members found near the surface or half-buried should be removed first (fig. 29–4).

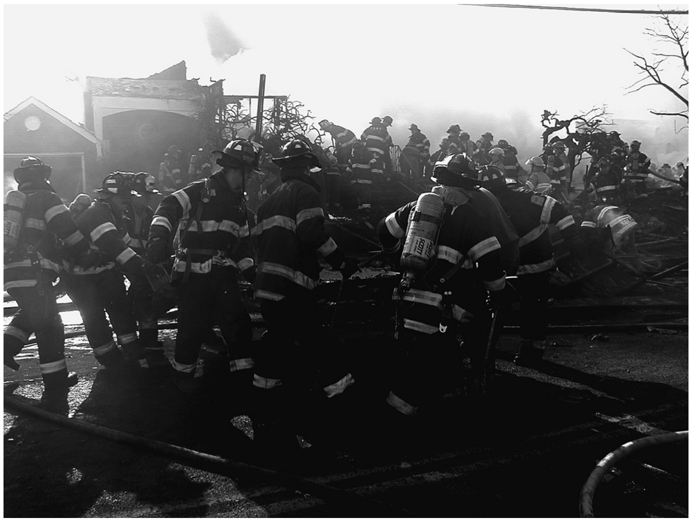

Fig. 29–4. The fourth step of collapse search-and-rescue plan is to remove surface victims.

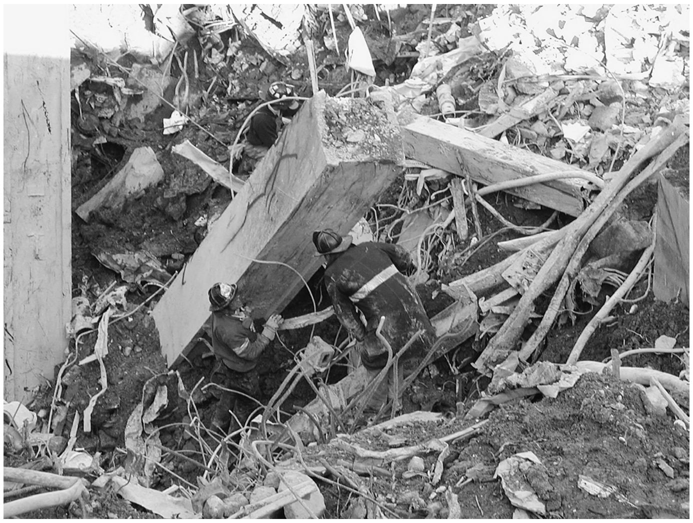

Fig. 29–5. The fifth step of the collapse search-and-rescue plan is to search voids and crevices for victims.

Fig. 29–6 The sixth step of a collapse rescue plan is take a time out; and analyze the collapse site for dangers and specific locations where victims could be buried.

While surface rescue takes place, the officers in command may order all voids that could contain a trapped firefighter searched (fig. 29–5). Void search is where firefighters examine spaces created by large sections of floors or walls that create crevices in which victims may be alive.

Voids or spaces that are stable and accessible through small openings may be quickly entered in the search. Firefighters may shine lights and call out to possible victims in small voids. Some voids that have no avenues of access and have large concealed spaces should be cut open and examined.

After all surface victims have been removed and all voids searched and examined, the next stage of the collapse plan should be started. This is the selected-debris removal, or tunneling and trenching. Before hand-digging trenches and tunnels to search for buried victims, all rescuers should be removed from the collapse rubble. A time-out and a safety assessment should be ordered by the officer in command (fig. 29–6).

During this break, another 360° safety survey should be conducted of the entire site. The history of collapse rescue reveals that after the surface victim removal and the void search and rescue, 75% of survivors have been rescued from the rubble. History also tells us the cost-benefit ratio turns against the firefighter rescuers at this point. The risk of death by a secondary collapse becomes great to the firefighters, and the likelihood of finding victims alive becomes less.

Tunneling and trenching is not a hit-or-miss operation. Firefighters are not told to just start digging through the rubble. During this selected-debris removal stage of a rescue operation, rescuers dig to specific areas where a victim was last seen or a specific point where a victim could be expected to be trapped. This location is based on an analysis of the collapse. The rubble is removed by hand from the collapse site to a specific location. Trenching or tunneling is advanced until the specific area or destination to be searched is reached (fig. 29–7).

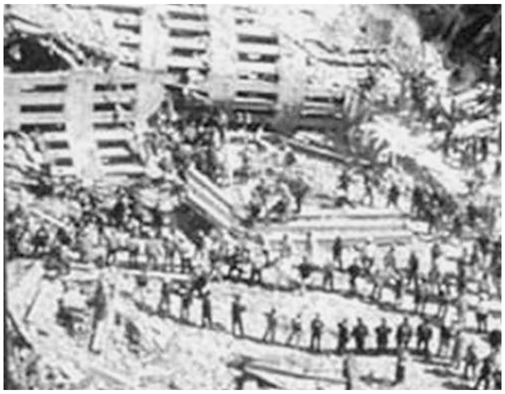

Fig. 29–7. The seventh step of a collapse search-and-rescue plan is to tunnel and trench to specific locations where victims are determined to have been trapped.

General-debris removal is the last stage of a collapse rescue plan. Even if all firefighters are accounted for, general-debris removal should be performed. There may be a person buried in the collapse who no one reported missing. At this stage of rescue, there is little chance of survivors.

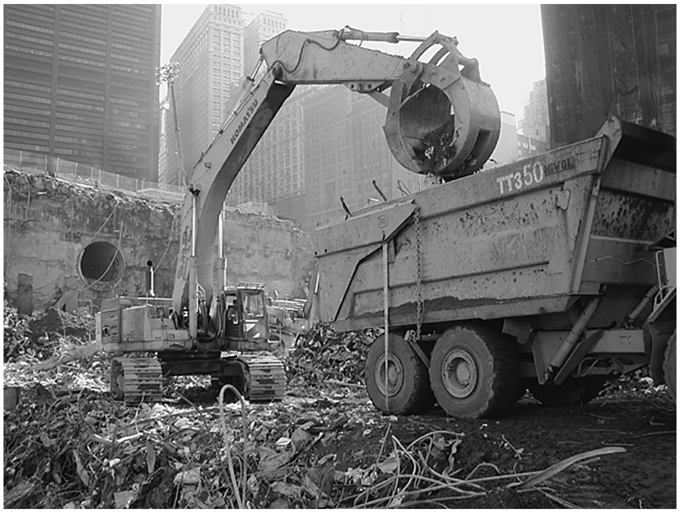

Fig. 29–8. The eighth step of a collapse search-and-rescue plan is to remove all the debris with mechanical equipment.

A mechanical crane may be used to lift large structural pieces from the collapse; however, each load of wreckage lifted out by a crane's bucket should be spread out on the ground and examined by firefighters (fig. 29–8). Then, it should be reloaded on a truck for transportation from the scene. The final dumping ground for all collapse rubble should be made known to the officer in command.

Victim Tracking

One of the most important and complex tasks facing rescuers at a collapse rescue operation is locating and identifying victims. Most victims will escape the collapse by their own efforts. However, some victims will be buried in the collapse rubble. A victim-tracking officer is assigned to determine the exact number, the names, and the locations of buried victims.

The victim-tracking officer is one of the most important personnel in a collapse search-and-rescue operation. This officer gathers information, analyzes the building collapse, and makes a determination as to where individuals have been buried. This information is necessary before tunneling and trenching to a specific location begins.

Before rescuers start tunneling and trenching, a victim-tracking officer must be able to state the following:

- The missing person has been confirmed, by a coworker, to have been inside the building during the collapse.
- The person is not safe at a nearby hospital, in an ambulance, or at a first aid station and has not left the scene and gone home.
- The exact area and floor where the victim was last seen, before the collapse, should be provided.
- An analysis of the collapse could shift the victim in the rubble during the collapse to a specific location. For example, if it is assumed that a person was on a floor during a collapse, then a V-shaped collapse of the floor would shift the victim to the bottom of the V. A lean-to collapse of the floor would shift the victim to the lowest end of the collapse. A tent or A-frame collapse of a floor would shift the victim to the lower outer ends of the collapse. A pancake collapse of several floors may not shift the victim; instead, the victim would fall straight down with the collapsing floors.

Police, fire marshals, and firefighters must be assigned to assist a victim-tracking officer at a large collapse rescue operation. These investigators must question survivors and check hospitals, ambulances, and first aid stations. They may have to visit residences of reported missing victims to confirm that those people did not leave the scene and go home.

Safety for Overall Collapse Rescue Operations

Safety can be ensured by following a stepwise procedure, summarized as follows:

1. Direct the police to secure the area. Barricade the entire collapse area. Police should be stationed at entrances and exits from the collapse site. Remove all people from the collapse site and prevent unauthorized people from entering the secured area.
2. A hose line must be stretched and charged at a collapse rescue operation. If a gas pipe breaks or a container of flammable gas or liquid is ruptured during the collapse, there may be a fire. To protect rescuers searching or digging at a collapse site, a hose line or, better, a tower ladder master stream must be ready to extinguish a sudden fire.
3. There must be a collapse rescue plan of action. The first reaction at an explosion or collapse is to rush onto the collapse pile and assist victims. This can be ineffective when it is done without a plan or coordination.
4. Remove all secondary collapse dangers that may fall on rescuers. After site survey, utility shut-off, removal of surface victims, and void search have been accomplished, all rescuers are called back from the collapse site and a time-out is taken. A second safety size-up and utility shut-off confirmation are ordered. By this point, 75% of victims have been saved. Before tunneling and trenching is started, all secondary collapse dangers are removed; the utilities must be confirmed shut-off, and during darkness of night, the collapse site must be illuminated by searchlights for the safety of rescuers.

5. Use a surveyor's transit telescope to measure any movement of walls, columns, or floors of the collapse structure. If movement is discovered, remove rescuers, shore up the structure, or remove the unstable structure.

6. Establish a command system for the collapse rescue operation to improve coordination and organization. Designate an interagency operations officer and notify all police, fire, emergency medical services, and construction rescue workers of who is in the charge of the collapse rescue phase of the operation. All rescue workers report to this interagency operations officer.

7. Set up fire lines around the collapse site to prevent injury to media or sightseers. Allow only fire, police, medical, and construction personnel inside the fire lines.

8. For the safety of rescuers, restrict the use of mechanical equipment such as cranes near the location where they are hand-digging. Place an officer in charge of the use of cranes, payloaders, and dump trucks for coordination and safety.

9. Use search dogs in dangerous areas for inspecting voids or crevices where victims may be trapped. All rescuers handling dogs must be informed of the training signal exhibited when a victim is discovered: when a search dog discovers a live buried victim, it is trained to bark and scratch the ground; when a dead victim is discovered, some dogs are trained to sit quietly at the location.

10. Temporarily suspend collapse rescue when severe weather conditions exist, such as lightning strikes or tornadoes; also, heavy rainfalls may cause concrete to absorb water weight and collapse on rescuers.

11. Assign sector officers to critical areas of the collapse site. Sector officers could also be assigned to each of the four sides of the building. A sector safety officer should be assigned to any dangerous area of a collapse rescue operation.

12. Ensure that all required rescue tools are brought to the collapse scene:
    - Circular saws and chains are the workhorse tools for collapse rescue operations in wood or ordinary-constructed collapsed buildings.
    - For collapsed buildings of reinforced concrete and steel, shovels, buckets, and steel bar cutters are the workhorse tools. Collapsed pieces of a masonry structure cannot be removed and placed in buckets or lifted by cranes until the steel reinforcement bars (rebars) are cut and the concrete is broken up. Tunneling and trenching to specific locations requires mostly steel bar cutters and concrete-breaking and -lifting tools. Eventually, firefighters will use tools for hand-digging and for placing small chunks of broken concrete in small buckets and passing them along in a human chain.
    - Video search cameras are used to search small voids and crevices. A 12-foot probe with a light and lens at the tip is inserted into small voids; connected at the other end is a firefighter with a small television set suspended by a sling around his neck. If victims are seen, up close observation of the video camera probe, monitoring for breathing and eye movements, can sometimes reveal whether a victim is alive.

- A sound-sensing device called a seismic/acoustic detection system is used to listen for the cries of buried victims. A sound probe is placed on top of or near a rubble pile where victims are suspected of being trapped.
- Vehicles with mounted light towers should be used during darkness. The light is directed from above, instead of from the ground up; this keeps the glare out of the eyes of the rescuers. Lights directed from below a pile of rubble can blind firefighters and can cause fall injuries.
- An important tool for use at collapsed reinforced-concrete structures is the rebar cutter. These hydraulic or electric cutters slice and cut the exposed rebars holding the broken and collapsed concrete together. Manual bar cutters, hydraulic and electric rebar cutters, power saws with metal cutting blades and oxyacetylene cutting torches are also used for cutting the rebars, but the hydraulic rebar cutter is the most effective.
- Exothermic metal rod cutting torches are also used to cut the rebars. The metal rod exothermic torch cuts faster than an oxyacetylene torch and is safer to use because it does not use acetylene gas. Both the oxyacetylene torch and the exothermic torch can be used in a backpack unit, allowing rescuers to climb into the collapse pile and operate in remote areas.
- Jackhammers are used to break up large pieces of concrete after the rebars are cut. Pneumatic jackhammers powered by large compressors are more powerful than engine-powered jackhammers or hydraulic and electric jackhammers, but they are heavier and cannot be used easily in horizontal positions. Hydraulic and electric concrete breakers prove their usefulness when working in confined spaces.
- The fire service can expect more collapse rescue operations as buildings age—and as new construction uses more lightweight materials and as older buildings are renovated and rebuilt under a performance code that allows lightweight materials.

30

FIRE GROUND SAFETY

An incident commander must have a plan for maintaining safety at a fire. Rapid fire spread, collapse, explosions, hazardous material release, and terrorists' bombs are some unexpected deadly events that occur at a fire. These events present dangers above and beyond the normal dangers firefighters face. The incident commander must be ready when any disaster happens during a fire operation. The following are some safety strategies that an incident commander can use to protect firefighters at a fire.

Rapid Intervention Teams

An incident commander must have a rapid intervention team (RIT) or a ladder company standing by during a fire to rescue a trapped, missing, or injured firefighter. The RIT helps a chief react to one of the worst emergencies that can happen on the fire ground—a missing or trapped firefighter. The RIT and the two-in/two-out rule of the Occupational Safety and Health Administration (OSHA) has recognized that sometimes the rescuer becomes a victim. A fire company or RIT standing by at the command post must be ready at all times to start a search and rescue during the fire or emergency incident (fig. 30–1).

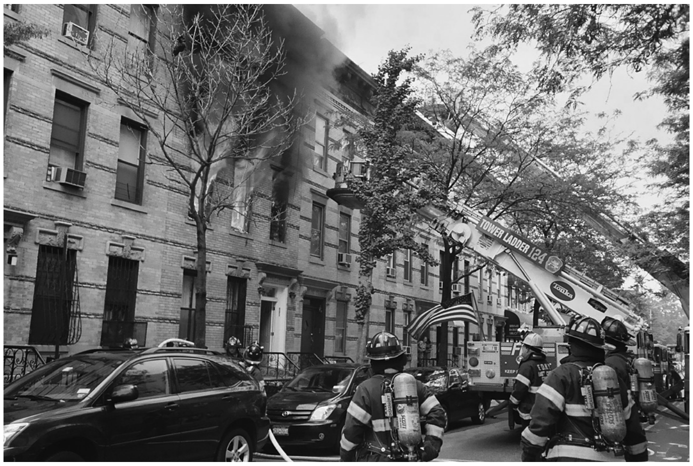

Fig. 30–1. RIT standing by at the command post.

The RIT should have masks, a search rope, and a rescue rope to allow a quick entry into a smoke-filled area. They should have or know where to obtain at a moment's notice a ladder, chain saw, circular saws, and lights. The RIT should not leave the command post unless ordered by the command chief. The RIT should not be used for firefighting unless there is sudden a life hazard. If used for rescue of an occupant of a burning building, the RIT must be replaced immediately, in case a firefighter becomes trapped or missing.

Some incident commanders call two RITs to a working fire; that way, if a civilian life is suddenly discovered to be endangered, one RIT can be used to save lives, and the second will still be available for a trapped firefighter. On the rare occasions when RITs are used for firefighter entrapment—when a firefighter is involved in a collapse, explosion, or fire entrapment—another RIT is most often required as a backup or for support of the initial team. Thus, a proactive incident commander should consider having two teams standing by at the command post when resources allow.

Accountability

An incident commander should have a system of accounting for firefighters operating at a fire. An accountability system—tags, riding lists, computerized tracking system, electronic chips, or GPS—is designed to assist an incident commander with command and control and to prevent firefighters from becoming lost or trapped during a fire.

The accountability system helps supervise the movements of everyone operating at the incident. Accountability prevents freelancing, which can lead to unnecessary reports of missing or lost firefighters. However, chiefs, company officers, and firefighters must understand that you cannot delegate accountability to a system. Everyone has accountability.

Everyone at a fire has a responsibility to be accountable. For example, the officer in command is ultimately accountable for all operations in the fire area. However, the incident commander can realistically communicate with and supervise only the sector officers. The sector chiefs, the chiefs, or the company officers in charge of parts of a fire ground are accountable only for companies in their sector, and the company officer is accountable for firefighters in the company. Most important, each firefighter is accountable to the officer of the company.

A guideline for assisting accountability during a fire is that firefighters must operate within sight or hearing of the company officer unless equipped with a portable radio. To ensure accountability during a fire, the incident commander needs the assistance of sector officers, company officers, and firefighters. The incident commander cannot do it alone. The incident commander needs the help of sector officers and company officers to share the accountability. Accountability systems help, but we must realize we create accountability, not the system.

Size-up

The incident commander at a fire should establish an outside command post in front of the fire building and size-up the fire. However, there should also be an operations commander for an inside size-up. Size-up strategy should be accomplished both from inside and from outside a burning building. The operations officer could be the fire officer in charge of the initial hose line or the officer of the interior search operation. These officers often make an inside size-up and report conditions to the incident commander outside the burning building, at the command post, who will make the outside size-up. The incident commander will request a size-up from the inside operations officer, and then make an analysis of the fire and transmit a radio status report of the operation based on both size-ups.

At most fires, during the initial stage of a fire, when flames are confined to one floor, the inside size-up is more accurate. The fire officer inside the structure is closer to the fire and obviously can see more of it than someone standing outside. However, when a fire spreads through the roof or involves two or more floors, the outside size-up becomes more accurate than the inside size-up. The fire officer inside the building can see the fire only on one floor and cannot see the amount of fire burning above, in the roof or on the floor(s) above. From the officer's limited viewpoint inside, he or she may believe that the fire involves only one or two rooms on the burning floor and that the blaze can be quickly extinguished, when, actually, the entire building is involved in fire above the officer and there is a danger of collapse. A good safety strategy at a fire is to conduct two size-ups—one inside and one outside—during a fire.

Communications

A fire chief must ensure that firefighters are equipped and trained to transmit fire ground communications. This means that every officer in charge of a company must have a portable radio to transmit messages to the command post. In addition, every firefighter who works out of sight or hearing of the company officer must also be equipped with a radio. The hard part of managing fire ground information is training firefighter to use the radios correctly. Company officers and firefighters are responsible for notifying the officer in command of structural hazards discovered.

Firefighters sometimes erroneously believe the warning to get off a roof or back out of a cellar when fire and smoke are increasing beyond the control of the hose line will come from the chief standing outside, at the command post. This is a major misunderstanding. This misunderstanding has cost lives. The truth is, the incident commander standing outside, at the command post, cannot see fire conditions inside the building. The chief cannot see the crack of the rear wall or evaluate the stability of the roof. Actually, the incident commander is depending on the firefighters, fire officers, and sector officers—who serve as the eyes of the incident commander—to report these dangerous conditions. Once the incident commander is notified of the danger, safety action must be taken to protect the firefighters at the scene. After many tragedies, firefighters, company officers, and sector officers come forward and tell of seeing warning signs before the event that they did not report to command. Sometimes lives were lost as a consequence.

Remember that fire ground hazards are discovered by firefighters and company officers operating in and around the burning building, not by the incident commander standing outside the burning building, at the command post. Fire ground warning communications come up the chain of command, not down the chain of command. During a fire or emergency, danger warnings come up the chain of command, while safety actions come down the chain of command. The incident commander can transmit an order to safeguard firefighters only after the danger has been reported to the command post.

Fire Ground Designation

The fire ground area must be defined, and everyone must know the defined area. Exposure A is the front of the fire building.

The command post is usually located at exposure A; proceeding clockwise when viewed from the command post, exposure B is the left side of the fire building, exposure C is the rear of the burning building, and exposure D is the right side of the building. When you give orders from the command post or receive orders from fire officers working around the building, you must use this or another fire ground designation system that identifies the four sides of a burning building. It is very unsafe if firefighters do not know where they are operating around the outside of a burning building. Also, if the fire chief cannot relay a message on the portable radio that pinpoints the exact side of a burning building where a hose line should be stretched or a where to search for a victim trapped at a window, there can be no command and control at a fire. If a fire ground designation system is not used by the chief and firefighters, then everyone can be considered to be freelancing.

Subdividing

Sectoring is the subdivision of a fire ground into smaller, manageable proportions. Sectoring increases supervision at a large or complex fire area where large numbers of firefighters are operating. A sector officer is assigned to a sector of the fire area. For example, a sector can be a chief or company officer assigned to exposure 3, the rear of the burning building. Alternatively, a sector officer can be assigned to a roof sector or an interior sector for fire suppression.

According to the incident management system, the fire or emergency area can be divided into divisions, groups, or sectors. A division, on the one hand is the subdivision of the fire ground into geographic areas. A group, on the other hand, is the subdivision of the fire ground into functions such as vent, extinguishment, or search. A sector is an assignment given to a chief or company officer that includes both a geographic area and a function.

Collapse Dangers

Establishing a collapse danger zone is a safety strategy that an incident commander can use when there is a danger of wall collapse. This is the most deadly area on the fire ground. Firefighters should not be allowed inside the collapse danger zone once it has been declared (fig. 30–2).

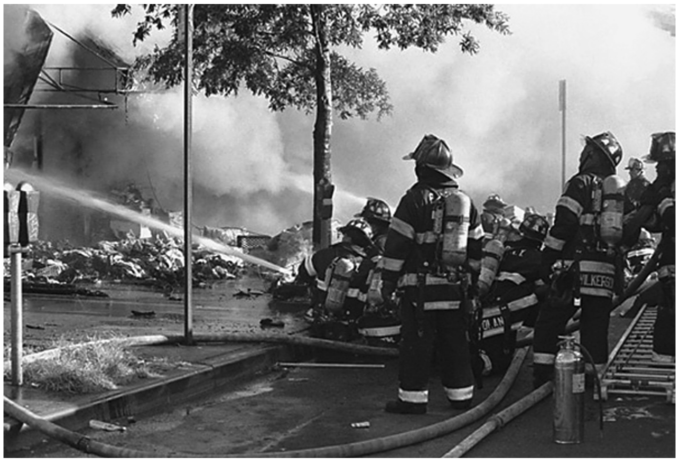

Fig. 30–2. The firefighters are outside the collapse danger zone.

The collapse zone is defined as the ground area that a falling wall would covered with bricks or other materials during a collapse. The collapse zone occupies that distance from the foot of the unstable wall and extends out for a distance equal to the height of the wall. When a brick or wood wall collapses in a 90°-angle collapse, it will kill any firefighter operating near the wall within the collapse danger zone. For example, a 20-foot-high wall collapsing at a 90°-angle will kill firefighters operating closer then 20 feet from the wall.

Flanking

Flanking a fire is another safety strategy that can be employed when a tall structure is involved with fire and there is danger of a wall collapsing or explosion. At such a fire, the establishment of a collapse zone could require firefighters to be positioned so far from the front of the building that the hose streams do not reach the fire. The reach of the average hose stream operated by firefighters is 50 feet. During a fire inside a church or heavy timber five-story mill burning building, for example, a collapse zone might require hose streams to be operated 70–80 feet away from the burning building to protect firefighters from a falling wall or explosion. In such an instance, instead of establishing a collapse zone, a fire chief may order the positioning of firefighters' hose streams in a flanking position. The chief would order that the hose stream be operated by firefighters from a position in front of the adjoining buildings on each side of the burning building. The hose stream range and effectiveness will be reduced, but the life safety of the firefighters will be ensured, even if the unstable wall falls outward beyond the collapse danger zone.

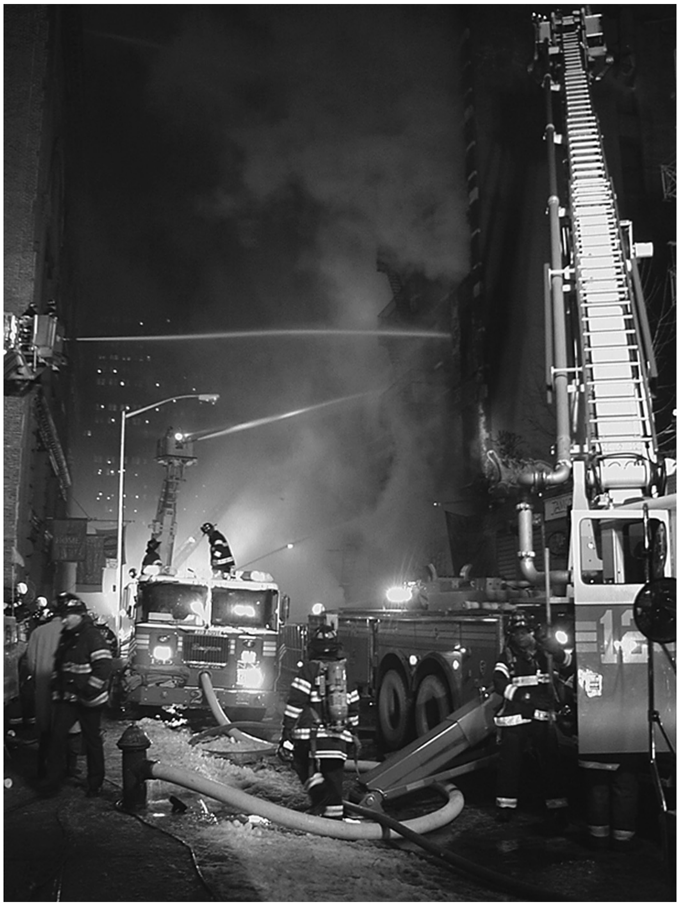

Fig. 30–3. The aerial master streams are flanking the fire. Firefighters in buckets are operating on each side of the building frontage.

Positioning Apparatus

These are areas of survival when there is a danger of wall collapse during an outside attack in a burning tall building. Sometimes establishing a collapse zone will position firefighters too far from the front of a burning. A hose stream has a reach of 50 feet. A 60–70-foot-high building in danger of collapse will require a collapse zone (a distance away from the building wall equal to the height of the building) greater than the reach of the hose streams. This will be the case with church and heavy timber mill buildings.

When we look at the fire ground around a tall burning building from a bird's-eye view, we see that there are only four areas in which to park apparatus and operate master streams—the four corner safe areas (fig. 30–3). If all the walls of a tall burning building collapse outward simultaneously (which is very unlikely), fewer bricks would land in the four corners of the fire ground. These are the four corner areas.

Probability of survival is greatest in the four corner safe areas. When there is danger of collapse, a safety strategy used by an incident commander is to position aerial streams, portable deluge nozzles, and deck guns on pumpers inside the four corner safe areas.

Light

During a nighttime fire, the incident commander should order the area lighted for increased observation of hazards and structural defects, as well as for increased visibility in the vicinity of the fire ground. A pump operator or ladder chauffeur should, when time permits a break from other duties, quickly direct apparatus spotlights on critical areas of the fire ground (fig. 30–4). For example, a spotlight may be directed on a window where a ladder is positioned, so that firefighters moving from the ladder into the window can see during this maneuver. Another light may be directed at a window where smoke or flames are escaping, and yet another light may be directed at the front entrance, where the hose has been taken. Lights can also be directed at structural defects, such as dangerously leaning chimneys, cracks in brick walls, and cornices that have partially collapsed. Spotlights may be directed at specific areas on a burning building. Floodlights, which disperse the light waves, should be used in addition to spotlights.

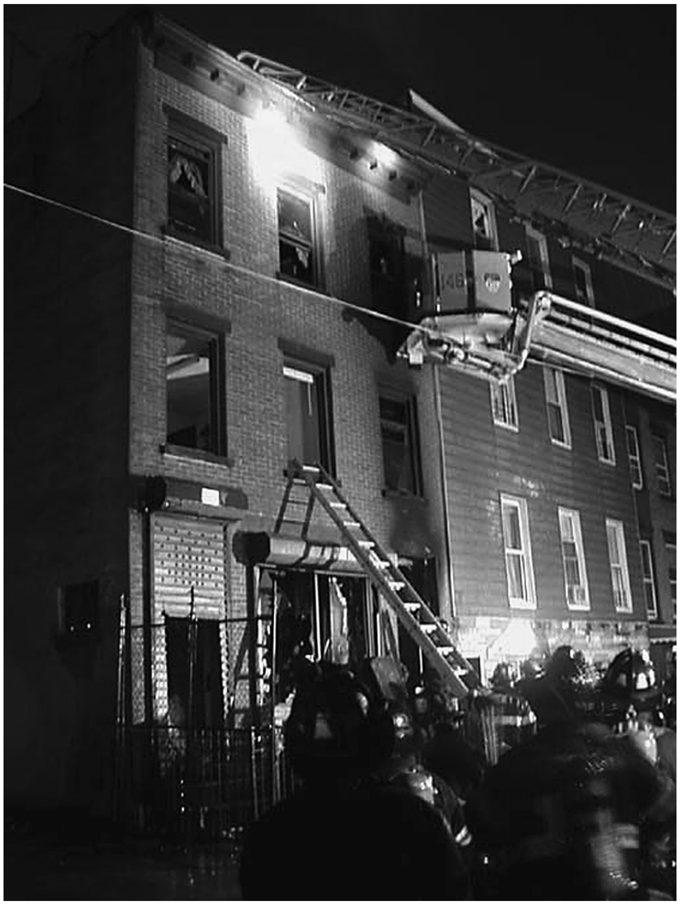

Fig. 30–4. The front of the building has a spotlight at a window and each floor laddered.

Floodlights are more effective at a fire scene. Floodlights will light up the entire area and will provide good visibility in general. Today fire apparatus have a lighting tower, a telescoping vertical tower that is either manually or electrically raised 10–20 feet above ground level and shine lights downward. Lights shining from above do not blind firefighters as do lights placed on the ground. Ground lights are directed upward into the eyes of firefighters. They sometimes blind firefighters coming down front steps and firefighters climbing out of windows onto ladders.

Safety Inspection

The incident commander may order a survey of a burned-out building by a safety chief before overhauling begins. After a fire building has being destroyed by flames, pounded with master streams, and deluged with tons of water (that has since been absorbed into the dried-out wood and plasterboard walls), a sudden collapse could occur during overhauling operations, after the fire has been declared under control. A safety inspection should be conducted before firefighters are sent in to overhaul such a dangerous burned-out building. The phase of a fire when collapse danger is greatest is during the overhauling stage.

The safety officer can be requested to inspect the building's structural interior stability to determine the destructive effects from the fire, the powerful master stream, and the accumulated water. The safety chief and another firefighter or officer conduct the survey. The safety inspector notes the following dangers: floors containing storage of heavy machinery, excessive vibration of floors, and charred and weakened floor decks (which could disintegrate when stepped upon). The safety inspector also observes the condition of stair treads and landings and estimates the weight of accumulated water that has been absorbed into broken and burned plasterboard that has fallen to the floor and estimate that has been absorbed into storage materials. Based on these factors and other safety conditions, the investigating officer may recommend that the chief in command prohibit firefighters from reentering the building for overhauling.

Hydraulic Overhauling

When a safety inspection determines that the building is too dangerous to have firefighters reenter to conduct salvage and overhaul, the chief can use hydraulic overhauling. The term surround and drown describes the long-term use of master streams to quench smoldering or spot fires after a fire has been declared under control. Water from deck pipes, an aerial stream, and a portable deluge nozzle can be used to put out a fire completely and prevent a rekindle, instead of sending firefighters inside to turn over and pull apart smoldering rubble (fig. 30–5).

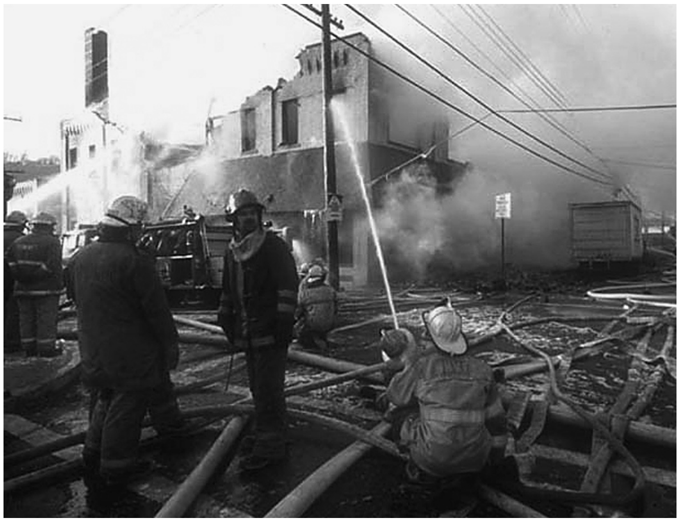

Fig. 30–5. Firefighters conduct hydraulic overhauling (defensive overhauling) with a master stream.

The outside master streams must be positioned outside the collapse zone. Water from master streams will soak down through smoldering content and structural material. Hydraulic overhauling is often effectively used on a vacant or burned-out structure that has become too dangerous. The fire chief and firefighters must have patience. It will take some time, but the smoldering ashes will be quenched without endangering firefighters.

Watch Line

A watch line is an overhauling strategy in which the chief leaves one engine or ladder company on the scene all night or several days, to wet down the smoldering building with an aerial stream or a hose line. Firefighters do this and watch the fire to see that it does not rekindle. If it does, they notify the chief, and he calls the companies back to the scene. During cold or unusual weather conditions, firefighters who are on duty at the watch line over night can be rotated every three or four hours.

The usefulness of a watch line is often overlooked. It can prevent risk taking during overhauling. It also absolutely prevents the possibility of a rekindle, because we do not leave the scene. Instead of rushing and taking risks to put out the spot fires in a dangerous building, leave a small number of firefighter on the scene to maintain a fire service presence—a watch line.

Partial Withdrawal

When a company officer reports an increase of fire beyond control or a collapse danger, the incident commander may order the partial withdrawal of firefighters. They withdraw to a safe location inside the building as interior firefighting continues. This strategy can be followed only when the construction of the building is known in detail—and when the fire spread or collapse danger is not life threatening. For example, this can be done when a ceiling collapse is possible or when the building has a stairway enclosed by a masonry wall and the stair landings are known to be independent of the occupancy landing. Firefighters can be withdrawn to the safety of the stair enclosure before the ceiling collapse occurs.

Some structures are divided into sections that are separated by fire walls. This design allows the roof of one section to collapse without affecting the integrity or stability of the fire wall. In this situation, a fire company could be withdrawn from one section of the burning structure and continue interior firefighting from a horizontal opening in the fire wall in the safe section of the structure. When this action is taken, ceilings of the safe section should be opened up to check for poke-through holes in the wall. Flames often spread through fire walls and party walls when workmen punch holes in them to run air ducts or electric wire.

There is one caution. A fire chief must realize all walls dividing section of a building are not true fire walls. For example, a party wall (a bearing wall supporting roof or floor beams of adjoining buildings) is not a true fire wall. It is tied into the roof or floor on each side. Collapse of a roof or floor on ether side of a party wall may affect the stability of the other side of the wall. A fire wall is not a bearing wall; it is independent from the rest of the structure. Moreover, it will not affect one side of the building when the other side collapses.

Complete Withdrawal

An incident commander may direct firefighters to withdraw from an interior hose line firefighting attack with their hose and equipment and set up an outside, defensive master stream attack on a burning building. The following are collapse warning signs that would justify this drastic action of withdrawing firefighters:

- Expanding cracks in a masonry wall
- Bricks falling out of walls
- Walls separating at the corners where exterior walls meet
- A structure leaning to one side
- Roofs from which joists have fallen or that are extremely spongy when walked on
- Floors and roofs that give the sensation of swaying or moving with supporting walls
- Floor or roof joists that appear to be pulling away from masonry walls
- Vibrating floors that are lower at the center because of deflection or overload
- Steel columns or girders that are out of plumb, warped, sagging, twisted, or fallen
- Severe slanting or cracking of a plaster interior walls or ceilings, which may indicate a shifting of structural framework behind the sheathing
- Cracking, rumbling, or cracking sounds coming from a structure
- A large body of fire in an old structure

Emergency Evacuation

Veteran fire chiefs know there is a difference between withdrawing firefighters and calling for an emergency evacuation. An emergency evacuation of all firefighters from a burning building is justified when a collapse has actually occurred or there has been an explosion or chemical, biological, or nuclear materials release. It is a more drastic action.

During an emergency evacuation, unlike a withdrawal, fire department tools and hose lines are left behind, and all firefighters immediately leave the building or fire area. A roll call is conducted by unit commanders, as there may be missing firefighters. An emergency evacuation is a rare occurrence in the fire service, and because of its rarity, there is usually confusion and delay when it is ordered. For this reason, fire departments should train their members for an emergency evacuation. Firefighters should exit the building or work area on receipt of a prearranged signal, leaving behind tools and equipment, which they can recover later, after the danger has passed. Firefighters should know the prearranged signal that distinguishes the more serious emergency evacuation procedure from a withdrawal.

31 POSTFIRE STRATEGY

Rekindle is a dirty word in the fire service. The term rekindle is used by firefighters to describe a blaze that reignites after they leave a scene. It describes the situation when, after salvage and overhaul have been completed and a blaze is officially declared extinguished, firefighters go back to the firehouse only to be called back to the burning building later, to fight the reignited fire. Sometimes, the second fire is much larger than the first. Worse yet, sometimes the second fire kills people who assumed the first fire was extinguished.

A rekindled fire is an indicator of a poor firefighting operation. Fire chiefs and fire officers have been subjected to legal action—and in some instances forced to resign—when in command of a blaze that was officially declared extinguished but reignited after the fire company left the scene. A rekindle is a nightmare of chiefs, officers, and firefighters.

Firefighters perform overhauling operations to prevent a rekindle. Frequently, we are criticized unfairly for damaging a person's house or business because we must ensure that the fire is not smoldering in concealed spaces or furnishings. Firefighters with pike poles, pry bars, and axes must break open plasterboard walls, pull apart mattresses, and throw out smoldering stuffed chairs. We cut up expensive floors and roofs after a fire has been extinguished to ensure that the blaze does not reignite.

Before salvage and overhauling operations begin, there are several actions an incident commander should perform:

- Conduct a collapse danger survey and rope off danger areas (fig. 31–1);
- Set up portable fans to remove toxic smoke and gas;
- Set up portable lights and power supply;
- Shut off gas and electric utilities;
- Determine fitness of firefighters, selecting those most able to perform overhauling and resting and rotating others;
- Call fresh companies for overhauling if necessary.

Every member of a fire company shares the responsibility during the salvage and overhauling operations of ensuring that a rekindle does not occur. This is an important team responsibility of firefighting. I learned this years ago, after

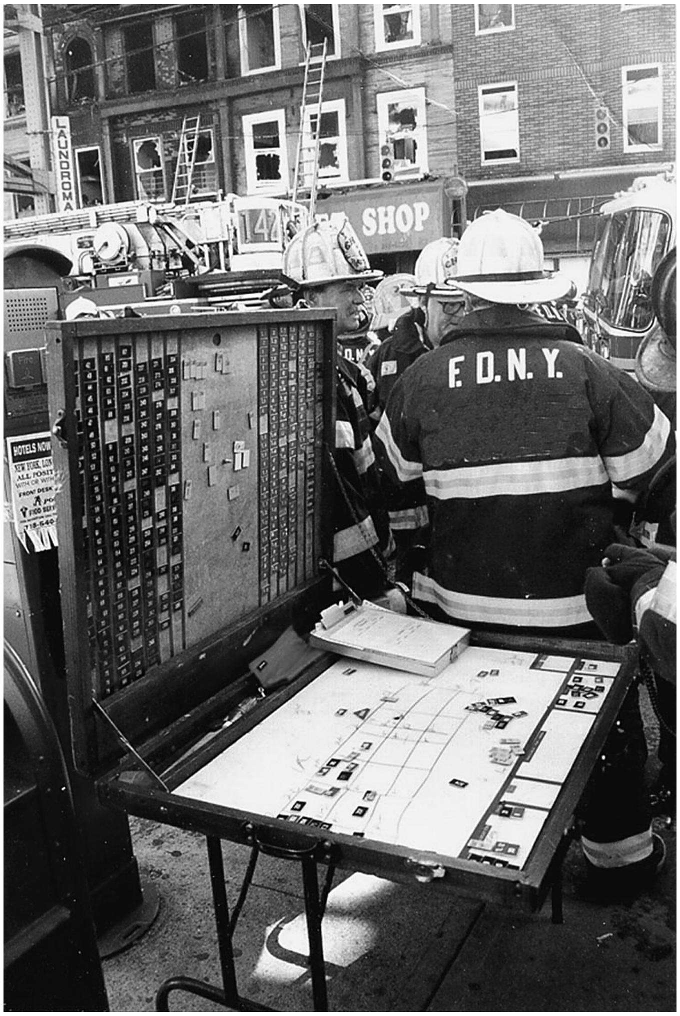

Fig. 31–1. Before salvage and overhauling a building, the incident commander should order that a safety chief inspect the burned-out building for hazards and determine whether firefighters should be allowed inside to overhaul or use a master stream for defensive overhauling.

extensive salvage and overhaul operations in a restaurant—a grease duct fire in a kitchen whose chimney ran along the walls of a high-rise office building. After a survey of the scene, a battalion chief and I agreed that the fire in the duct had been extinguished.

Over the portable radio, we ordered the last engine and ladder company inside the building to *take up*. A veteran firefighter came to the command post and heatedly insisted to us the fire was still smoldering in the grease duct. He said he could still detect heat coming out of the chimney flue, on the roof. He was right. We did more overhauling and prevented a rekindle. That firefighter saved reputations that night—including mine.

After a serious blaze, chiefs, company officers, and firefighters are exposed to many physical discomforts. They may be soaking wet, freezing cold, have headaches and be exhausted from the exertion of firefighting. There may be emotional discomforts as well. They may be frustrated or angered by events surrounding the fire, the strategy, the tactics, or because one or more of their comrades have been injured. Such discomforts and emotions caused by the aftereffects of firefighting can interfere with decision making during salvage and overhauling. Time becomes more important than looking for smoldering embers.

Everyone subconsciously wants to return to the firehouse for dry clothes, a meal, and some rest. “Get it done, and let’s get back to quarters” can often be heard during overhauling. The final responsibility for overhauling strategy rests with the incident commander, who should ensure that the proper overhauling strategy is implemented, to prevent a rekindle.

What Materials Smolder and Rekindle

Veteran fire officers know what types of materials are difficult to extinguish fully and are susceptible to rekindling. They have passed down to us how to conduct an effective operation overhauling smoldering material, and how to prevent a fire from reigniting after we have left the scene. Burned and smoldering mattresses, bedding, and stuffed chairs are the materials that are the most difficult to extinguish fully. Mattresses can smolder inside the box frame, then flame up hours later. Also, the inside of a cushioned chair can sometimes be hollow and contains air that can keep a fire smoldering for hours. The exterior surfaces of stuffed bedding and stuffed chairs are frequently coated to prevent the penetration of liquids. A stain-resistant coating intended to repel spilled liquids will also prevent water from a hose stream used during overhauling from penetrating a deep-seated hot spot of a smoldering fire.

This furniture must be cut open with knives to be wet down effectively. The danger of a rekindle is so great that firefighters should remove a mattress or stuffed chair from the fire building even after it is quenched with water during overhauling. The mattress or stuffed chair is taken to the street and quenched under a hydrant outlet or a waiting booster line stream.

Foam cushioning is another material that can conceal a smoldering fire. Foam mattresses, pillows, and seat cushions contain small air pockets in which fire may get oxygen for smoldering combustion. In some instances, the foam is a plastic material that contains in its air pocket highly flammable hydrocarbon residue.

Ordinary clothing, when hanging in a closet, can conceal a smoldering fire. Pockets of air between the layers of clothing—and the added problem of plastic covering over clothing returned from a dry cleaner—increase the chance that a smoldering fire will go unnoticed. Burned clothing must be removed from the closet, pulled apart, and wet by a hose stream. When it is removed from the closet during overhaul, the smoldering clothing may flare up, revealing the rekindle danger. Clothing in drawers inside of a piece of burned, charred, and smoking furniture must be examined for smoldering fire during overhauling. When flames burn a piece of furniture and char the clothing inside the drawers, any blackened and burned folded clothing must be removed from the drawers, pulled apart, and wet with a hose line.

Piles of burned and charred cardboard, newspapers, and rags must be pulled apart by firefighters, and the insides must be wet with a hose stream. All cardboard contains pockets of air. Newspaper and rags, when folded and placed in piles, contain tiny air spaces that let a fire smolder without visible signs on the outside. Charred and partially burned stacks of cardboard, paper, and rags, especially those tied with wire in large bales, must be opened and pulled apart, and the inside must be quenched with water to prevent a rekindle. Overhauling when there are stacks of cardboard and papers is a long operation; patience is required to prevent a rekindle.

Rubbish in the cellar storage bins at the bottom of compactor chutes is another rekindle hazard. During overhauling when there is a compactor or incinerator rubbish, the refuse must be pulled from the storage bin onto the cellar floor, separated, and wet with large quantities of water to ensure fire extinguishment.

Concealed spaces in the vicinity of a fire must be carefully examined during overhauling for smoldering fire. The most common concealed spaces to be opened up and examined for hidden fire during overhauling are the ceiling above a fire and a window frame. After a chair or mattress fire is extinguished, the first piece information a fire chief wants is whether the fire and heat have spread to the ceiling space above the burned furnishing. It is opened with a pike pole. Firefighters must open up the plaster ceiling until they reach a space where there is no sign of char or burning. A thermal-imaging camera is a useful tool when overhauling. Hot spots behind plasterboard ceilings and walls can be detected. The thermal-imaging camera can prevent excess damage when overhauling.

When a room-and-content blaze becomes so large and hot that it has melted the glass and flames flow out of the window, chances are great the fire has spread into the cracks around the window frame and into the concealed space around the top and sides of the window. This concealed space may contain combustible material and smolder. Inside the concealed space around a window, there may be combustible rope attached to weights for the up-and-down mechanism. Also found smoldering in this concealed space may be wood shavings, paper, or combustible insulation. This material may have caught fire from the flame burning out the window and it could smolder inside this concealed space after the fire is extinguished. When the window frame is charred and this is suspected, the inside framing around the window is removed during overhauling to expose any hidden fire. This is called trimming the window.

Using a pike pole from inside the room, a firefighter first removes the top molding over the window. Then, the window frame molding is pulled from the wall. A clear view of the concealed space around the window will be available. Water from the hose stream should be directed into the now-opened concealed spaces around the window. In some instances, there may be a deep-seated smoldering fire in a rotting windowsill, and that too may have to be removed to prevent a rekindle. This requires an sharp axe to cut the center of the thick windowsill. Then, the two severed sections can be pushed out the window opening.

Grease inside a kitchen exhaust duct can continue to burn and rekindle when hose streams are directed from the roof above down through the duct or when the stream directed upward from the kitchen does not reach and fully cool down the burning grease. A rekindle in a grease duct often takes place at the point where a vertical sheet metal duct changes direction and becomes a horizontal section of ductwork. If this horizontal section of kitchen duct is not cleaned properly, large accumulations of grease can build up in its horizontal sections. If there is no opening for cleaning the duct at this point, feel the sheet metal for heat, use a thermal-imaging camera, or cut open up the duct and examine if fire is suspected.

Cellar oil fires from defective burner units can be easily extinguished with foam or a fog nozzle, but after firefighters leave the scene, a more serious fire may occur in the apartments above, due to a rekindle. The heat and flames may have spread undetected into the ceiling space between the cellar and the first floor of the structure. Unless the ceiling above the oil burner is opened up with pike poles or a concrete ceiling is carefully examined above, there could be a rekindle in the beam above the oil burner, which could spread throughout the building after firefighters leave the scene.

One of the most difficult overhauling operations that I undertook, after a fire was extinguished one night while I was a battalion chief, was a cellar oil fire that heated the concrete ceiling above and spread fire to the floor above. After the oil burner fire was easily extinguished, we discovered that the fire had heated the concrete floor and ignited the wood furring strips of the first floor. We began to cut open a finished oak floor and the subfloor. Smoke was seeping up through the wood as we cut. Fire had spread to two-by-two strips of wood embedded in the concrete above the oil burner. The wood strips were the framing underflooring for the oak floor. We had to extinguish the fire and pulled up the wood furring strips embedded in the concrete floor separating the cellar from the first floor. The more of the oak floor we cut open, the more fire and smoke we discovered. After hours of cutting a beautiful oak floor and subfloor, we finally extinguished the fire. After that experience, I never failed to examine the ceiling and the floor above during an oil burner fire.

Material discarded in an air shaft during overhauling in a multistory row house can fuel a rekindle fire. One of the first lessons a new fire officer learns during the salvage and overhauling operation is to check the bottom of the air shaft after a fire is extinguished. Sometimes, victims trying to escape fire jump out a window and are found at the bottom of a shaft. You do not want to bury a fire victim with rubbish thrown into the shaft during overhauling. During the initial search, check the bottom of the shaft for victims who have jumped out a window to escape the fire.

If all persons are accounted for after a fire, before overhauling begins, check the bottom of the air shaft to ensure that there is not any smoldering fire. After a room-and-content fire in a structure has been extinguished, pieces of wood and rubble may be discarded in the shaft, rather than left in the apartment. It is easier for the building management to remove the rubbish from the shaft bottom through the cellar than from an apartment several floors up. However, before this is done, the bottom of the shaft must be examined to ensure that there is no fire that will be buried by the material thrown into the shaft. If there is rubble burning in the shaft and overhauling debris is thrown on top of it, after firefighters leave the scene, a rekindle in the shaft will occur. During overhauling, any material thrown into the shaft must be continually wet with a hose stream. And before leaving the scene, double-check the shaft. It must be thoroughly examined for any sparks or smoldering.

The cellar of a commercial building containing a large amount of stock is another area prone to rekindle after a fire. During overhauling in a cellar, a smoldering fire in tons of paper, boxes, or clothing will be difficult to extinguish. The confined cellar may not have space to pull apart the smoldering stock for quenching by a hose stream. While overhauling smoldering material in a cellar, you cannot throw the stock out a window or down a shaft. You may not be able to use a large amount of water because it may fill up the cellar if there are no drains. During overhauling in a cellar fire, the tons of stock may have to be carried up to the street and spread out and wet down. During overhauling after a long, serious fire in a cellar that contains a large amount of stock, the tendency of exhausted company officers and firefighters will be to take a chance and not remove the stock. This decision will increase the risk of a rekindle.

The incident commander should specially call fresh units to the scene to overhaul or consider mutual aid companies to relieve exhausted firefighters.

Controlled fires in old and historic town house fireplaces are another serious rekindle hazard. During the holiday season, fireplaces are used for long periods. Fire sometimes conducts through the hearth floor or the back wall of the fireplace to wood floors or wall beams. Fire can spread through cracked bricks or missing mortar in the fireplace structure.

The smell of wood burning when firefighters arrive at a call may be mistaken for a residual odor of burning logs; instead of causing damage to the house by opening plasterboard walls and baseboards in the apartment below during a holiday, when the house is full of guests, the inexperienced fire officer may decide not to examine the structural wood around the fireplace. This decision could lead to a more serious rekindle fire when the guests are sleeping. The best decision a fire officer can make is to check for hidden fire in a concealed space. If you have a thermal-imaging camera, this is a perfect job for it. If not, open up the ceiling below the fireplace. Examine the wood beam and framework around the fireplace hearth. It is best for everyone.

Taking Up

After the fire investigation, salvage, and overhauling have been completed, an incident commander must have a strategy for demobilization, or taking up. How a fire scene is left after firefighter leave the scene is very important. How a firefighting operation ends leaves a lasting impression on a community. This stage of a fire can be disorganized and disorderly, or it can be coordinated and organized if the following strategies are put into effect.

Crowds of firefighters

After fire or emergency operations, large numbers of exhausted firefighters will suddenly appear in the street or lobby of the fire building. They will not go away without orders. Instead of waiting for company officers to randomly come to the command post requesting to take up, the incident commander should have a strategy of what companies leave and when. To do this, a list of all companies at the scene must have already been completed at the command post for reference.

The incident commander must have a strategy to downsize the operation. Firefighters who performed the most exhausting work should be the first ordered to return to quarters. However, in general, the rule for leaving the scene should be as follows: first-arriving companies should be the first to go home, and last-arriving companies should be the last to leave. When companies are ordered to leave the scene, the commander should order unused hose and equipment to be picked up before units leave. Company officers must account for all tools and equipment. Lost fire department property must be reported to the incident commander before leaving the scene.

Overhauling and taking up injuries

After the flames and smoke subside, medical personnel at the scene sometimes ask the incident commander if they can be released. Don't let them go. The fire danger may have been extinguished, but the hazards of the ruins remain. Firefighters are often injured during overhauling and taking-up operations. Some hazards firefighters face during this end stage of a fire are ice and frostbite, carbon monoxide from smoldering materials, electric shock from exposed wires, falls, collapse of burned and weakened floors and ceilings, gas explosions, cuts and lacerations during the pulling of plasterboard ceiling and the removal of framework around doors and windows, and heat exhaustion.

Freezing equipment

After a fire has been extinguished and temperatures are below 32°F, the equipment must be protected from freezing. When fire companies must remain at the scene for extended periods of time, hose lines not being used should be drained and taken up before they become frozen in ice. Nozzles of lines to be used during overhauling should be kept slightly open at all times, even when not in use. Booster tanks should be drained, and aerial ladders should be lowered into to truck beds. Low temperatures for long periods can cause a raised ladder to be stuck in the upright fully extended position. Frozen rails, locks, and gears will prevent its retraction. As soon as possible after a fire is under control, the commander should order these actions.

Sanitation and Relocation

Water from hose lines and hydrants will turn streets and sidewalks into sheets of ice. This ice can cause falls, apparatus accidents, and traffic congestion. The public works department should be called to salt and sand the intersection and ice formations from runoff water. Victims of the fire will suffer cold and freezing unless they are given shelter. The Red Cross or the Salvation Army should be requested to respond to relocate or provide warmth for people burned out of their homes.

Determining the Origin and Cause of the Fire

When a blaze has been extinguished, the first strategy of the incident commander is to determine if the fire is suspicious. If terrorism or arson is suspected, call fire investigators to the scene; delay overhauling until the investigation is finished. Next, protect the occupant's belongings and furniture from overhauling damage, by having firefighters move them, or cover them.

The incident commander is responsible for determining the origin and cause of a fire. The investigation must be done before overhauling operations begin, because overhauling will destroy evidence. At most fires, a question asked of the occupant or a look at the room of fire origin will reveal the cause. If the arson investigator is delayed in responding, one or two firefighters or a company should remain at the scene until the investigator arrives. This will preserve evidence and establish a continuity-of-evidence supervision for a latter court trial if an arsonist is prosecuted.

Press Interview

The fire ground commander must speak to reporters. This is an important opportunity for the fire department to get across a fire prevention message or at least to promote the service delivered by the fire service. During the interview, a public safety message can be mentioned, along with the facts of a fire. The importance of automatic sprinklers, closing a door to the fire area, using smoke detectors, and replacing batteries in a smoke detector are some public safety messages that can be mentioned. We are sometimes called the silent service, because we are reluctant to tell our story. Don't let this happen to your fire department.

Before you speak to a reporter, think about the fire and what you will say. Most interviews are routine. The reporters will ask how many alarms have been transmitted, whether any deaths or injuries resulted, whether the fire is under control, and how many firefighters are at the fire. It's best to have the answers to these questions before the interview.

Money or Valuables Discovered during Overhauling

When money or valuable articles are discovered during overhauling, the incident commander should record the amount of money and the description of the valuable items. Valuables should only be turned over after identification and proof of ownership is confirmed. If the owner cannot be found, the money or valuable items should be turned over to the police. In either case, the fire chief should obtain a receipt from the owner or police. Money or valuables should not be given to friends or the manager of the building, only to the owner or the police. A record of the money or valuables and the name the recipient should be included in the fire report or in a logbook at the firehouse.

Traffic Congestion

After a fire where automobile traffic is delayed, the incident commander will be requested to move apparatus that are not being used. The chief will also be asked to estimate how long the overhauling operation will take. As soon as possible after a fire is under control, the incident commander should request that officers send chauffeurs of aerial ladders and pump operators to the street to reposition fire trucks to open streets to traffic. Intersections should be cleared first. If a roadway cannot be opened to traffic because of continued use of fire apparatus, consider opening up half of the roadway to traffic by repositioning fire trucks closer to the curb.

Salvage and Property Protection

Before leaving the scene, fire companies should be directed to remove jagged shards of glass from the frames of windows that were broken, to vent heat and smoke. Trim the broken glass from windows by pulling it back into the room with a pike pole. This reduces the chance of injury by falling glass to firefighters outside. After the window is cleared of broken shards, plastic covers should be stapled to the frame opening to prevent damage from rain and to preserve heat (fig. 31–2). This will prevent frozen pipes in the winter.

Vent openings in peaked roofs can also be sealed with plastic covers. Plastic covers should protect valuable furnishings. Sprinkler heads should be removed if they fuse during the fire. New sprinkler heads should replace them. The sprinkler system should be placed in service before leaving the scene of the fire.

Outside Agencies

After extinguishment, the incident commander must often request assistance from other agencies. Utility companies will be asked to restore gas or electric that

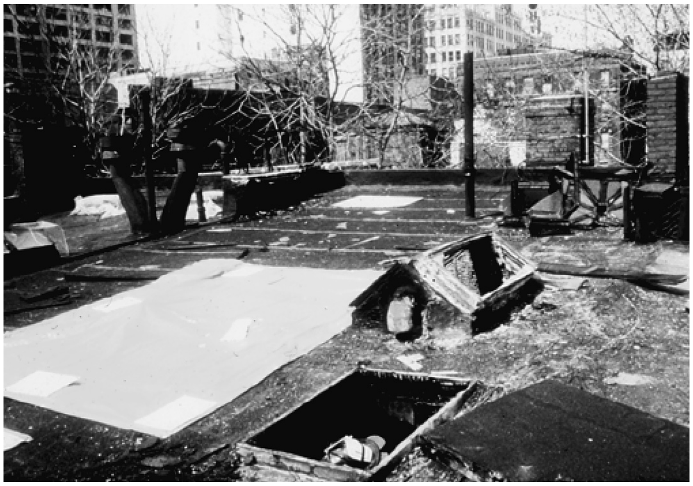

Fig. 31–2. Plastic salvage cover is placed over the ventilation roof cut to protect the top-floor apartment from the elements.

was turned off by firefighters. Firefighters should not turn on gas or electric supply after it has been shut off; if there is a mishap with the gas or electric, the fire department will be held liable. All doors forced open should be reported to the police officer in charge. The fire department should not leave a building unprotected after a fire, because looters may take valuables after we leave. If there is a question of the burned-out structure's stability or if there is a danger of collapse, the building department should be requested to send a structural engineer to evaluate the building. When there is a large amount of burned rubble in the street, the sanitation department should be notified for a bulk pickup of this debris. If water mains or fire hydrants have not worked properly, the water department should be called. If flames and smoke have contaminated food products for sale in a store, the Board of Health should be called to determine whether the food can be sold or should be destroyed. The Environmental Protection Agency should be called to the scene if waterways or sewers are contaminated.

Dangers at the Scene

The incident commander should ensure that the area is safe before leaving the scene. There may be collapse dangers, open sidewalk cellar doors, fire escape drop ladders, and counterbalance stairs that need to be reset and a burned-out shell of a structure into which children may wander. Ice or glass may cover a road or sidewalk. Before leaving the scene, the incident commander should order firefighters to safeguard the area. Fire escape access ladders should be returned to their original positions. All sidewalk openings should be closed or covered. Entrance doors should be relocked, and firefighters who are the last to leave should exit through windows and down ladders. Tape or rope indicating "Do not enter" should surround the danger area near collapsed or weakened structures. Police may set up barricades. At every fire, the premises are turned over to police for security. The officer's name and rank are recorded in the fire report.

The ending moments of any event can have a lasting impact. An incident commander must realize that the salvage overhauling and demobilization stages of a fire operation are very important because they leave the greatest impression of the entire firefighting effort with everyone in the community. The firefighters could have saved lives and made a great fire stop, but if the last part of the firefighting strategy—salvage, overhauling, and demobilization—is not done well, all the heroic efforts may be forgotten.

32 STRATEGY ERRORS AND FAILURES

If a football quarterback has a 60% passing completion rate during his career, he is considered a great quarterback. If a baseball player hits the ball 4 out of 10 times at bat, he may be inducted into the Hall of Fame. An incident commander must have a much better success ratio than those ball players, but an incident commander sometimes fails during firefighting. Sometimes the incident commander fails and the fire spreads, sometimes a fire victim is not discovered during a search, and sometimes everything that can possibly go wrong at a fire does go wrong.

To reduce strategy errors, we must continue to study the art of firefighting. We must study its principles, we must participate in hands-on training, and most important, we must put our learned firefighting knowledge into practice during fires and emergencies. Unfortunately, we sometimes learn firefighting by trial and error. When a strategy error happens, we must never forget it; we must ensure that the same mistake is not made a second time.

This chapter features some hard-learned lessons based on strategy errors that I and others have made. The purpose of writing about strategy missteps is threefold: first, to spare you from making the same errors; second, to avoid making novel strategy errors; and third, to admit that we all make errors of judgment during the chaotic life-and-death decision making of firefighting.

Insufficient Resources

When you are a recently promoted officer, there is a reluctance to transmit greater alarms. Rookie fire officers do not want to appear too quick to call for help. They do not want to appear unsure of their strategy and the ability of the firefighters to control a fire. Most of all, they do not want to call firefighters to the scene of a fire that does not need additional resources to control it. Most veteran incident commanders, however, would tell you it is no disgrace to transmit an alarm calling for additional resources and then unexpectedly have the fire quickly be extinguished. As one veteran told me, “Kid, when it gets lonely at the command post, send for some help.” I know I did this many times.

The term we use during an incident management resource utilization training session, to explain calling for more fire companies to the scene than is needed is being proactive. Transmitting additional alarms and having fire companies in staging areas for possible future use is good firefighting strategy. The general rule is that if you have all companies on the first alarm working, there should be an additional engine and ladder in reserve, in addition to the rapid intervention company. If there is a third-alarm working fire, there should be another alarm assignment standing by ready for action.

However, it is definitely poor firefighting strategy for a rookie or a veteran incident commander not to transmit an additional alarm when needed and have the fire spread because there are not enough fire companies on the scene. The incident management system taught at the National Fire Academy advises that it is best to be proactive when transmitting alarms. The objective is to get the resources to the scene before they are needed. An incident commander should have several companies at the command post and set up a staging area and keep reserve firefighting forces ready for action.

Protecting Exposures

I learned the importance of protecting exposures at a fifth-alarm fire one cold windy day on Riverside Drive, facing the Hudson River, as a rookie firefighter. I was directing a hose stream, without much success, from a fire escape into the top-floor window of a fourth-alarm fire. Several apartments on the top floor were fully involved. The fire escape was attached to the side of the fire building and separated by a narrow 15-foot alley from a similar six-story 100-foot-by-100-foot H-shaped ordinary-constructed apartment house, which was exposure B. Exposure A was the Hudson River. The entire top floor of an apartment building was burning.

A 30-mile-per-hour wind from the river swept fire across every top-floor apartment and into the common roof space. The wind was feeding the fire and preventing any hose line from advancing from the stairs or fire escapes. My hose line was on the fire escape in the alley on the downwind (exposure B) side of the building. The hose stream was making no headway on the horizontal sheet of flame coming out the window and blowing across the alley.

Suddenly, my officer shouted to me. Looking around, I saw that my officer was pointing to the building across the alley. At first, I did not see anything. Then, looking down to the street, I saw that the chief appeared very upset and was shouting up to our company. He was excitingly pointing to the exposure B building. Again looking across the alley to exposure B, I saw a very small fire on one of the wood window frames. Radiated heat or burning embers had spread fire across the alley, and a small fire was burning on the side of a window frame.

My officer ordered me to direct the hose line on to the exposure building and extinguish the small fire. At the time, as a rookie who did not know anything about firefighting, I could not believe everyone was getting so excited about such a small fire on the window frame of the adjoining building, when the entire top floor of the building that we were operating on was fully involved. I wondered why my officer and the chief were so excited about such a small fire. My officer quickly let me know why by turning me and the hose line that I was holding toward the small exposure fire. We concentrated the hose stream on to the burning window frame of the exposed building across the alley.

After the exposure building was protected by our hose stream and another hose line was stretched inside the building, we returned our efforts to the building of fire origin for an entire day. My officer later explained why we temporarily stopped fighting the big fire and extinguished the small fire in the exposure building. He stated that if we did not prevent the fire from spreading to the building across the alley and if the fire had spread throughout that building, we would have been firefighting the blaze for two days. I later learned the objectives of firefighting strategy: first, protect life; second, prevent fire extension; third, confine the fire; and fourth, extinguish the blaze. I have never forgotten those.

Strategy Error at the Command Post

Staying at the command post as an incident commander is difficult for a new chief. As a company officer, I was used to being inside the building, close to the action. Over the years as a battalion chief and deputy chief, I slowly learned how to conduct firefighting strategy and size up a fire from the command post. However, a friend of mine never learned this. My friend, when promoted to chief, kept going into the fire building and moving in with the first attack hose team. Instead of staying at the command post, he would leave his driver outside to give incoming companies orders while he was inside with the firefighters advancing the hose and searching for victims. Even after many years, this did not change. Everyone knew where my friend, the chief, was during a fire—inside with the hose attack team advancing the line. When my friend wanted a greater alarm transmitted, he ordered his driver to transmit an alarm. When a higher-ranking chief arrived he would ask where the chief was. The firefighter would say that he was inside with the engine company. After many years, even though this was not effective command and control, everyone came to accept this. This worked for many years because he was lucky enough to always work with good firefighters who learned how to command and control a fire from the outside, at the command post.

The procedure in the FDNY and most fire departments is for a chief to stay at the command post to give orders to incoming units and, when the higher-ranking chief arrives to transfer command, relate the strategy being used. After this face-to-face transfer of command, the higher-ranking chief has the option of sending the chief wherever there is need. An incident commander should not leave the command post. If there is an urgent need to go inside the burning building, the incident command must tell his aide to remain at the command post and must convey the destination of the interior visit; the incident commander must return as soon as possible.

During a fire, there should be a size-up from inside the burning building and a size-up from outside the burning building. The outside size-up is usually by the incident commander at the command post. The size-up from inside the burning building by an operations officer. During the initial attack, the interior size-up is most effective when the fire is on one floor. However, if the fire spreads to the roof or to two or more floors, the size-up by the incident commander outside, at the command post, becomes more accurate. In this situation, the operations officer inside cannot see the fire above and has a limited view of the overall fire spread. The incident commander must stay outside, at the command post; must rely on size-up information from the operations officer inside; and must not go inside unless there is a life-and-death problem.

Stretching a Backup Line

After one, two, or three hose lines have been stretched into a burning building and firefighters are advancing them toward the fire, sometimes there is no obvious need for another hose line; yet, the fire is definitely spreading, and you know you will need another line somewhere. This is not the time to tell a company to simply stand fast and have firefighters await further orders.

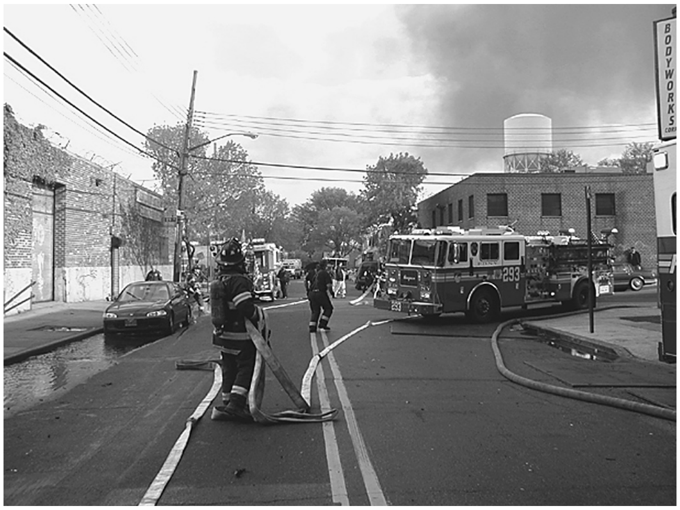

Fig. 32–1. When sufficient firefighters are on the scene, not having a prestretched hose line by a company standing fast in front of the fire building can be a strategy error during a fast-moving fire.

This is the time to have firefighters stretch a hose line to the front of the building and then stand fast. When you do this, you are being proactive with your hose line placement (fig. 32–1). If there is a sudden need for a hose line to cut off spreading fire in a building and the firefighters are already at the front of the building standing fast with the line, they can quickly take it inside the building. This is because the stretch has already been completed. The advantage of stretching a hose to the front of the building and standing by is that you have the fire company do most of the hose stretch before you decide where it is needed. The most time-consuming part of the hose stretch is already completed. The firefighters must find a nearby pumper, they must select a proper nozzle and hose size, and they must stretch the hose to the front of the building, with excess hose folded nearby. If the hose line is not needed, you can order the fire company to take it up. If you just have the company stand fast, and then a need for a hose line arises, the company will take much more time to get the hose where it is needed.

Utility Shut-off

Several years ago, while I was standing at the command post during an overhauling operation in a tavern fire after the blaze was knocked down, a firefighter in distress came out of the building, staggered over, and collapsed on the back step of a fire apparatus. I quickly went over an asked how he was. He said, “Chief, I was almost electrocuted!” While pulling the ceiling, his metal tool had become entangled in the electric wire in the ceiling. Sharp jolts of electric current shot through his wet gloves, into his arms. Unable to let go of the tool and unable to untangle it from the wires, the steady waves of electricity moved from his hands, down his arms, through his chest, and down both legs to the wet floor. The firefighter realized he was being slowly electrocuted. The electric current kept his wet, gloved fingers wrapped tightly around the metal tool. He tried to shout for help, but he could not. His jaw was locked shut by the jolts of electricity flowing through his body. He began to black out. He lost consciousness. As his body crumpled to the floor, his hands were pulled away from the metal tool, and he regained consciousness. Getting up from the wet floor, the firefighter staggered outside and stumbled over to the fire apparatus.

I realized that as the incident commander, I should have had the electric power shut off before the overhauling began. I quickly called over the radio, "Command to operations! Stop the overhauling! Send a firefighter to the basement to shut the power off." After the firefighter was taken to the hospital and the electricity to the store was shut off, the order was given to continue the salvage and overhauling operation.

This was a strategy error on my part, and I was very lucky that the firefighter was not electrocuted to death. Back at headquarters, I thought, What should be the strategy for shutting off power? When should I order the electric and gas shut off during fire operations? Generally, at a structure fire, electric power should remain on for as long as safety permits. Electricity provides power for lights, which assists search-and-rescue operations. It keeps fire pumps running for fire extinguishment and elevators operated by firefighters for evacuation. However, there are certain times during a fire or emergency operation when electric power should be immediately turned off to protect firefighters and trapped victims. I sent out a standard operating procedure to every company, as follows: Electricity should be cut off before structural overhaul starts. It may not be shut off for overhauling when only the content is burned, but when breaking open walls or ceilings near electric wires, the power should be shut off.

Normal current in a residential building can kill firefighters. During structural overhaul, walls, ceilings, and floors are often opened in order to search for hidden fire. Metal tools can come in contact with electric wires behind these walls and ceilings. Firefighters standing on a wet floor in a burned-out room can get a metal tool entangled in a live wire. This can cause the firefighter to be electrocuted or severely shocked. Thus, after a fire is extinguished and before extensive overhaul is started, electric power should be shut off. There are also times when electric power should be shut off immediately on arrival. Electric power should be shut off immediately whenever electricity is the source of the heat causing the fire. Here power must be immediately cut off before extinguishment. Also, if there is no fire but a victim is being electrocuted, power must be immediately diverted from the wire or appliance threatening the trapped person.

Power should also be shut off on arrival at explosions and structural collapses. An explosion and a collapse can rip open walls, ceilings, and floors of a structure and expose live wires. Also, live electric wires will be threaded throughout collapse rubble, hanging dangerously in midair or laying around the ground. Firefighters may come in contact with a wire. One of the most important actions after an explosion or a collapse damages a building is to shut off all the utilities—gas, water, and electric. Shutting off electric power can save the lives of searching firefighters and trapped victims in the collapse rubble. To handle this type of operation, firefighters must be trained to safely shut off electricity to residential buildings. Utility companies must be called to the scene when needed, but many times they cannot respond quickly enough to do the job.

Failure to Control the Fire Ground

I responded to a fire where a firefighter was injured by another firefighter, who threw a burned stuffed chair from a window. At this fire, a company extinguished a small blaze in a stuffed chair. Then, they removed a badly burned man who had fallen asleep in the chair with a cigarette and started the fire. Firefighters dragged the smoldering chair to a window, pushed it onto a fire escape, yelled, "Watch out below," and threw it over the rail into the backyard. Unfortunately, the outside vent firefighter was in the backyard, about to climb the fire escape. He was struck by the smoldering chair and knocked unconscious.

Again, this was a strategy error on my part. I was the incident commander. I am responsible for controlling the fire scene. I should have established a procedure for safely throwing burned and smoldering objects from a window. The next day, a standard operating procedure for throwing objects from a window in my command was issued, as follows:

1. Before discarding anything out a window, the officer must notify the incident commander.
2. The incident commander then assigns a firefighter to the area below the window, where the material is to be discarded, to clear the area of civilians and/or firefighters and to prevent injury and act as a safety guard.
3. After the area is clear, the firefighter in the street, acting as guard, signals when to throw the smoldering objects out the window.
4. When all objects have been discarded, the officer who is finished discarding the rubble out the window notifies the incident commander.
5. The firefighter acting as a safety guard notifies the incident commander that the operation is over and stretches a booster line to extinguish any smoldering rubble.

Failure to Protect Exposures

During a defensive firefighting operation in a large one-story row of stores or shopping mall, where the flames are shooting through the roof of several stores, hose lines are sometimes positioned on a roof behind a parapet wall in an attempt to save a portion of a building. The parapet wall is being used by firefighters as a barrier, and the hose lines are positioned along the wall being directed on the fire. A parapet wall is the portion of a wall that extends above the roof line. A party wall is the entire wall, above and below the roof, between two buildings or two sections of a large building and may act as a fire barrier. A party wall may support roof beams of two adjoining buildings or spaces. The brick wall may be eight inches thick and extend above the roof by three feet. Several hose lines positioned on the roof behind this brick parapet wall, directing streams at the burning roof, may look good and breed overconfidence.

The parapet wall and hose lines may look like they can stop any type of spreading fire, but don't bet on it! Party walls often have poke-through holes concealed below the roof and above the ceiling of the occupancy below. Fire may spread through the party wall beneath the roof where the firefighters are operating hose streams. When you use a party wall as a barrier to stop a spreading fire in a common roof space, always check the wall below the roof. Many times, the wall above the roof looks good, but the wall below the roof has holes, loose and missing bricks, and unauthorized openings for pipes and ducts.

When using a party wall as a fire barrier, order firefighters into the store below to pull the ceilings and examine the wall from below the roof. Fire may already be spreading through holes in the brick party wall. There can be large openings in a wall for air-conditioning ducts and pipes, or there may be spaces created by mortar cracks or missing bricks through which fire could spread. What you see above the roof is not what you get below the roof. When workers renovate a building containing a row of stores, they may rebuild the party wall section where it is visible above the roof, but the important portion below the roof is often left unrepaired. The strategy mistake and lesson learned is that whenever you position defensive hose lines on a roof behind a party wall, make sure that you check the store below.

The worst strategy error in my entire career involved a party wall. This party wall supported roof beams of two adjoining buildings. Fire burned through an eight-inch-thick brick party wall where wood roof beams from both buildings abutted. Fire spread to the entirety of exposure D, and it became a major-alarm fire. I was the incident commander directing a master stream defensive attack in a large, vacant six-story H-type building in the Bronx. Exposure D was a similar but much larger H-type building separated by a party wall.

I sent a chief to check out the party wall dividing the buildings. He reported that the party wall looked very good. It did, after the fire, we both checked it out. There was new capstone on top of the wall. The mortar between bricks was perfect: no cracks or missing bricks or mortar. However, despite the condition of the walls, the ends of the roof beams of the fire building, resting in the party wall, were back to back with the ends of the roof beams of the exposure building.

During the defensive master stream attack, fire burned the beam ends of the fire building and spread fire through the eight-inch-thick party wall to the exposure. I mistakenly relied on the positive report of the battalion chief's assessment of the wall's condition. I should have sent a hose line up to the top floor of the exposure and had the ceiling pulled and the area below the roof where the beam came through the wall checked, in addition to the top condition of the party wall. Never trust a party wall.

Elevators

A company in my division transmitted a Mayday signal. I responded and investigated. At this fire, when the first company arrived, a building manager, who had discovered a fire and transmitted an alarm, assured them that it was a small fire and took them up to the fire floor in the elevator. When the elevator car door opened, the lobby contained a roaring fire. The firefighters and building manager ran for their lives through the fire and fortunately escaped to the safety of a stairway.

Never take an elevator up to the fire floor even if the building manager tells you the fire is small. Never let anyone else press the floor destination button for you. As an officer, you should press the button for the selected floor. When using an elevator during a fire, determine the lowest floor where the fire has been reported and then take the elevator two or three floors below. Leave a firefighter in the lobby to inform arriving companies and the chief of the reported fire floor, the elevator being used, and the company in the elevator. After firefighters get off the elevator, they should send the elevator back down to the lobby with a firefighter operating the controls and walk up the stairs to the fire floor. Do not keep the elevator on the upper floors. Send it down for reinforcements.

Firefighters must always use the firefighter service when taking an elevator during a fire. If not, the elevator may take firefighters directly to the fire floor. In addition to the aforementioned strategy failure, there are several additional ways an elevator that is not used in firefighter service mode can malfunction and bring a firefighter up to the fire floor and almost certain death:

- A person on the fire floor who has escaped a fire pushes a corridor call button and then decides to leave by the stairs because the smoke and heat in the corridor become too severe.
- A firefighter can be brought up to a fire floor in an elevator during a high-rise fire if the corridor (mechanical) call button and wiring become deformed, deteriorated, and/or melted by the heat of the fire.
- During a high-rise fire, elevators are called to the fire floor when the electronic touch button (immovable, touch sensitive) is activated by exposure to dense smoke. Note that electronic call buttons do not operate by heat from a person's finger. This is a misconception. Electronic call buttons are activated by the completion, through the person touching it, of a circuit to the ground. Dense smoke can complete this circuit.

The following safety and survival tactics must be employed when using an elevator during a high-rise fire, even one with a phase II (firefighter service) mode. First, accurately determine the location of the fire floor on arrival. Be aware that a person reporting a fire from the 12th floor of a building may have seen smoke and flame outside the window rising from below, on the 11th or the 10th floor.

Even when a building employee tells you the floor where the fire has been reported, check the computer or video terminal for a smoke detector signal. The floor on the alarm ticket, the floor on the alarm panel, and the floor reported to you by the person in charge of the building must all be the same. When they are not, or when several floors on the alarm panel indicate that smoke detectors have activated, assume that the lowest floor is the fire floor.

Use an elevator that has a phase II (firefighter/emergency service) mode, but realize that this system may fail. Take the elevator two or more floors below the reported fire. If the fire is located on the sixth floor or below, walk up the stairs instead of using the elevator.

Hose Placement

In a multistory building, the first hose line is usually stretched up the interior stairway to the fire floor, and the second hose line is stretched as a backup. If the first line extinguishes the fire, the backup line is usually sent to the floor above, to stop any minor fire spread.

Once, I did not follow these hose placement guidelines during a fire, and it almost became a disaster. The fire occurred on the second floor of a four-story multiple-dwelling building of ordinary construction. An inexperienced firefighter was assigned to perform forcible entry.

On arrival, flames were blowing out one window, which led directly to a fire escape on the front of the building. The first hose line had already been stretched up the interior stairs and charged with water. You could hear the firefighters' tool-pounding attempts to force the door; we did not have the rabbit tool then. After I ordered a second hose line, flames broke out of a second window and began to spread into an open window on the floor above. An unusual radio report from inside stated that they could not force open the heavily padlocked apartment door.

As firefighters stretching the second hose passed in front of me, I redirected them to stretch up the fire escape and advance in on the fire through the fire escape window. As a young incident commander, I used to pride myself as being able to quickly "think outside the box," as they call it today. I also ordered the hose team inside to bring the hose up to the apartment above to stop the autoexposure fire spread. As the firefighters advanced through the burning apartment from the fire escape, disaster struck! The forcible-entry team suddenly forced open the door to the second-floor apartment. The firefighters advancing the hose from the fire escape drove flames out into the public hall and up the interior stairs.

Now I had fire spreading up the interior stairs and a fire company with a hose line trapped on the floor above the fire. After several Maydays, the firefighters who took the initial hose line up the interior stairway fought their way back down with the hose, and the firefighters advancing the hose from the fire escape window extinguished the fire in the second-floor apartment. After the fire was out, I realized what an error of hose placement I had made. The following lessons were demonstrated:

1. Forcible entry is of extreme importance.
2. The first hose line goes to the seat of the fire, attacks the fire from a door, pushes the fire outward, and protects the interior stairway.
3. The second hose line should back up the first hose line and if necessary goes to the floor above.
4. A hose line should not pass the fire.
5. When a door is forced open, it is important to control the door and not let it swing open into the flaming apartment. A gloved hand or a six-foot hook can sometimes reach in and close a door, or a rope tied to the doorknob during forcible entry can be used to control the door.
6. It is not always good to think outside the box during life-and-death emergency operations.

Hose Stretching

I responded to a second-alarm fire, and on arrival, there seemed to be a problem. Everyone was yelling, and several hose lines were being stretched. A 2½-story private dwelling had flames coming out the front, side, and rear doors. The incident commander at the scene had firefighters stretching three hose lines simultaneously. When I arrived, which was several minutes after the second alarm was transmitted and 10 minutes after the initial alarm, none of the hose lines was charged with water and operating on the fire. People were shouting on each side of the burning building for the firefighters to attack the fire from a different location around the building.

When I arrived, I said to the incident commander, "Let's have all the firefighters stop what they are doing and work together to get one hose line in operation."

Sometimes we attempt to do too much. Sometimes it is best to focus on one task and accomplish it before starting the next task.

The lesson in strategy error and learned that day was, supply water to the first hose line before you start stretching the second and third lines. Most fires are extinguished by one hose team, so hose lines should be stretched one at a time, and water should be supplied to them one at a time. Do not stretch two or three lines simultaneously.

During the initial attack on a burning building, flames and smoke may be visible at several locations. Fire may be evident at the front door, rear windows, and side alleys. People in the street will call for help from several locations and urge you to stretch hose lines to several different places at the same time. If three or four hose lines are stretched at the same time to different locations, this can create a disorganized operation and actually delay water from being delivered into the fire. Firefighting resources will be fragmented and ineffective. Generally, it is more effective for all firefighters on the scene to stretch one hose line at a time. Get water in this first hose line before you start another. All the firefighters are needed to connect the pumper to the hydrant, choose the nozzle and hose, stretch the hose from the pumper to the fire, and charge the hose with water. After this is completed, start the second line after the second hose line is stretched, and start the third line if necessary.

Failure to Locate the Fire

Fire Commissioner Augustus Beekman's final report to the Mayor of the City of New York about the Waldbaum's Supermarket fire, on August 2, 1978, where six firefighters died in a timber truss roof collapse, stated on page 1, "the location of the fire had not been clearly defined prior to the collapse taking place." The same could have been said about the 23rd Street floor collapse where 12 FDNY firefighters died and, more recently, about a floor collapse on June 5, 1998, on Atlantic Avenue, in Brooklyn, where Captain Scott LaPiedra and Lieutenant James Blackmore died in a floor collapse.

The location of a fire inside a burning building must be determined on arrival at the scene. If there is going to be a successful interior attack, the floor of fire origin must be determined. At some fires, there is so much flame and smoke coming from a building that you do not need to enter the building. At other fires, building alterations prevent us from accurately locating the fire. However, at most small fires, the first officer enters the building, locates the source of flames, and sizes up the fire.

Only after location of the fire can strategy be decided on and implemented. Subsequently, hose lines can be stretched to the correct location, and ladders can be properly positioned. Furthermore, only after you locate the fire can the correct number of apparatus and firefighters can be called to the scene to control the blaze. The location of the fire will reveal the best way to approach and attack the blaze—what door, what stairway, what window.

Sometimes we take the act of locating a fire for granted. This is because it is so obvious, it is done so routinely. However, every so often, the first-arriving companies cannot immediately locate the source of fire in a smoke-filled building after an extensive search. When this happens, strategy and tactics suffer, and often there is a loss of life.

Failure to Supply the Sprinkler

An incident commander must always size up the front of a burning building to determine if it has a sprinkler system siamese. If it does, the system must be supplied with water. At some fires, the incident commander does not see the sprinkler connection or overlooks the sprinkler siamese and first stretches a hose line to the fire. Fire departments have been sued to compensate for fire damage when a sprinkler system was not supplied with water by firefighters or when the water supply to a sprinkler from a water main was shut down or diverted to pumpers and hose lines.

A sprinkler system can extinguish fire quicker and more effectively than firefighters. This is because the sprinkler head is already in position directly over the fire, and water supplied to the sprinkler is not impeded or slowed by locked doors, blinding smoke, or failure to locate the fire. However, when a building has both a sprinkler system and a standpipe system and firefighters enter the building to fight the fire, the first supply line to the siamese should go to the standpipe system. This is to protect the firefighters. The second supply line should be connected to and supply the sprinkler system.

Protecting Exposures at Strip Store Fire

The firefighting strategy of locate, confine, and extinguish the fire is incomplete when firefighting at a strip mall with a common roof space. This strategy statement is incomplete, leaving out one of the most important objectives of structural firefighting: to prevent fire spread. Fire officers sometimes ask, “What’s the difference between confining a fire and preventing fire spread? Isn’t it the same firefighting strategy?” The answer is no. Preventing fire spread is different from confining a fire. It has a higher priority than confining the fire.

Preventing fire spread should be accomplished before you confine the fire. A friend of mine learned this lesson as a new battalion chief. At a fire in a row of stores in a one-story structure with a common roof space, he had the first hose line operating in a store and then ordered the second hose line to be positioned into the exposure store on the upwind side of the strip mall fire. He ordered the third line stretched into the downwind store. Flames had already passed the downwind exposure and spread into two stores through the common roof space.

When a line is sent to the downwind store, it is to prevent fire spread. When a line is sent to the upwind store, it is to confine the fire. The lesson learned is to send the second hose line to the downwind exposure in the ordinary-constructed strip mall with a common roof space before you protect the upwind store. The firefighters with the hose line in the downwind store must pull ceilings near the partition separating the burning store and stop any fire from spreading in the common roof space. When stretching hose lines, the strategy is as follows:

1. Protect life hazard with the first line
2. Prevent fire extension with the second hose line
3. Confine the fire with the third and fourth lines
4. After the fire has been surrounded, direct all hose lines to extinguish the fire.

Positioning Apparatus

At one of my last major fires before retirement, at a fire in a row of stores in the Bronx, a parapet wall collapsed into the bucket of an aerial platform, seriously injuring several firefighters. When I arrived at the fire, the parapet wall was an obvious danger, so I ordered everyone off the roof and out of the building and switched the strategy from an offensive to a defensive attack. I specially called two battalion chiefs, in addition to the two at the scene. I assigned each one an exposure. Because of the dangerous parapet, I assigned one battalion chief to exposure A, the front of the stores. I never did this at any other time in my entire career.

Over the radio, I warned everyone — the sector officers of exposures A, B, C, and D included—of the dangers of the parapet wall. I personally went to the front of the building and ordered several firefighters off the sidewalk. I told the officers in command of two aerial platforms to operate their tower ladder buckets above the parapet wall. When the safety chief arrived, I told him to watch out for the parapet wall.

Suddenly the parapet wall collapsed—moments before I ordered the officer of a tower ladder to move the ladder into position at exposure A, in front of the fire building, and to use the aerial master stream at the fire. The apparatus had just been repositioned in front of the fire building. The chauffeur positioned the ladder truck outside the collapse zone. However, the bucket was raised from the bed and lowered to the sidewalk inside the collapse zone, so that two firefighters could climb into the bucket. As the firefighters stepped into the bucket, before it was raised, the wall collapsed. The two firefighters had just opened the swinging door and stepped into the bucket when the wall came crashing down on them. One firefighter suffered a concussion and the other had a broken collar bone and a dislocated shoulder. They were rushed to the hospital.

My strategy error at this fire was that I should have restated to the company officer of the tower ladder the danger of the parapet wall when I ordered him to position his ladder at the fire. However, there was a strategy error on the part of the sector chief in charge of exposure A, where the collapse occurred. He was also responsible; he too, should have notified the officer to watch out for the parapet wall. Finally, the company officer's strategy error was that he should have ordered the bucket lowered to a spot outside the collapse zone, so that the two firefighters could safely climb into the tower ladder bucket.

The lesson I learned from these firefighting strategy errors is that it is much easier to identify a collapse hazard at a fire than it is to manage the fire ground after the hazard is identified. Another lesson I learned at this fire is that fire ground safety takes teamwork. One person at a fire does not create a safe firefighting strategy. As the incident commander, I bear the ultimate responsibility for the injury of these firefighters and safety of all firefighters at the scene; however, a sector officer and a company officer are also accountable for the safety of firefighters operating under their command.

An Offensive and Defensive Attack

When I lecture around the country, I show a video clip of a fire in a 2½-story private dwelling. Fire is in the attic, and firefighters are standing on a decorative cornice separating the second floor from the attic. The firefighters are directing a 1¾-inch hose stream in the attic. At the same time, a tower ladder master stream is attempting to extinguish fire in the building's roof near where the firefighters are standing on the cornice. The water stream comes dangerously close to the firefighters standing on the cornice, operating with the hand line. As the aerial stream strikes the building, it appears to be lifting the roof away from the building with the force of the stream. Suddenly, the cornice, with the firefighters standing on top, collapses. The cornice, firefighters, and hose line crash down onto a porch roof below.

After the video ends, we discuss the strategy errors. There is a strategy error of too many firefighters on the cornice, as well as a strategy error of the firefighter's directing the master stream in such a way as to weaken the roof and pull it away from the cornice. But the strategy error everyone in the class agrees on is the simultaneous use of an offensive strategy and a defensive strategy. The incident commander's error was to have a defensive master stream operating and an offensive 1½-inch hand line in operation on the fire at the same time. An incident commander could use either an offensive attack or a defensive firefighting strategy—but not the two strategies, offensive and defensive, at the same time.

Most fires are extinguished by an offensive attack. However, when the incident commander changes to a defensive strategy, he or she is required to withdraw firefighters to safety. When master streams are used, firefighters engaged in an offensive attack with a hand line must be withdrawn to safety. If the defensive attack is to be temporary and the offensive attack will be restarted after the master stream is shut down, the firefighters may be temporarily removed to safety on a floor below. However, if the defensive attack is to be the final strategy, all firefighters must be removed from the burning building and positioned outside the collapse zone. The lesson dramatically shown in the video is that an incident commander should not use an offensive attack and a defensive attack using a master stream at the same time. The firefighting strategy should be an offensive attack or a defensive attack, not both together.

When Your Strategy Fails

What does an incident commander do if the firefighting strategy fails completely? What does an incident commander do if the fire is so unusual that there is no known strategy? What can an incident commander do when there are insufficient resources to control a situation? How can an incident commander employ firefighters to combat a disaster for which there is no precedent? Here is how: The incident commander must use the priorities of firefighting to make strategy decisions.

The priorities of firefighting are moral and legal ways of making strategy decisions. These priorities never change. The first priority of firefighting is to protect life at the scene. This includes the lives of the firefighters at the scene. Thus, if there are no civilians at the scene or occupants of a burning building in danger, you take every measure and make every decision solely to protect the responding firefighters. The priorities of firefighting require you do not unnecessarily risk the lives of firefighters. As the risk managers state, do not sacrifice good life for bad (dead) life; do not sacrifice life for property. If you do not have a strategy, take steps to safeguard the firefighters until you decide on a strategy. You may make any decision that you believe is best to safeguard life. If there is no known strategy, do whatever it takes. If there is no strategy, there is no precedent. Make sure everyone gets back to the firehouse safely. The next step in the priorities of firefighting is fire containment. After you ensure that the civilians and firefighters are safe, then control the fire.

Fire containment is the second priority. Fire containment is not as important as the lives of the civilians and the firefighters. After an incident commander has protected the life hazard, then make whatever decision you believe is best to control the fire. Let the fire spread if you have to save lives. The lives of the people come first. There is no exception to this: life first; fire containment second. This is a moral and legal obligation of firefighting strategy. Fire control, the second priority, starts with preventing its extension. Flank the fire if the spreading edge is too rapid for a frontal attack. Next, surround the blaze, and after it is confined, either let it burn out or move in and extinguish the fire.

Finally, the third priority of firefighting is property protection. After you ensure that all lives are safe and the fire has been confined, take all steps to protect property. Firefighters take an oath to protect life and property in their community. However, we are not an insurance company; we are a fire department. Property protection is important, but it is not more important than the lives of the people in the community and the firefighters' own lives. Nor is property protection as important as fire containment. For example, we must sometimes force open doors and damage property to gain access to a burning house to save lives. Also, we must sometimes break windows and damage property to vent smoke and heat, allowing firefighters to contain a fire. Sometimes we must break open a plasterboard ceiling or wall to check for hidden smoldering fire that could spread unnoticed after we leave the scene.

In conclusion, when an incident commander does not have a firefighting strategy to use at a fire, all strategy decisions must be made according to these priorities of firefighting: life safety first, fire containment second, and property protection third. This is the foundation of firefighting. If you can remember only one firefighting strategy in this book, this is the one.

33 SECONDARY STRATEGIES

(FOR SMALL PROBLEMS)

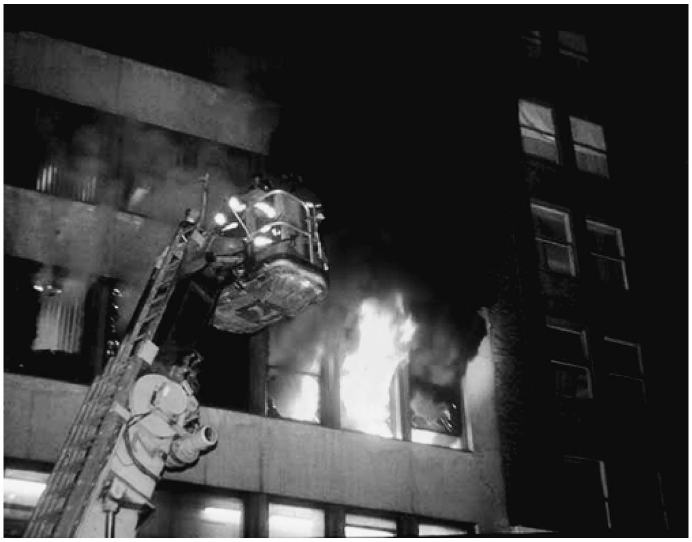

Fig. 33–1. The strategy to control autoexposure is to have an outside hose stream directed at the spandrel wall, above the flames, not in the window.

The firefighting strategies in this book are primarily for large fire problems. In addition to strategies for large fire operations, there are small problems that crop up at fires that require secondary or small strategies. An incident commander must know small plans to solve these small problems that arise at fires. If enough of these small problems arise during a fire and they are not controlled by the incident commander, they may interfere or delay the accomplishment of the overall firefighting strategy. The following are what I call secondary or small strategies for small fire ground problems.

Autoexposure Firefighting

Autoexposure is defined as the spread of flame from one window to the window above. A strategy used to prevent fire spread by autoexposure is to order outside stream directed at the spandrel wall between windows (fig. 33–1). Do not direct the outside stream into the flaming window if other firefighters are operating inside. If it has been confirmed that all occupants and firefighters are not inside the building, a hose steam can be directed into the flaming window to stop autoexposure.

Backdraft

The strategy to prevent a backdraft explosion in a store during a fire is to immediately vent the store occupancy by opening the roof skylight or roof scuttle. Roof venting may neutralize an explosive smoke atmosphere in the store. Even if an explosion occurs, the roof vent may divert the blast upward through the skylight away from the path of the advancing firefighters.

Collapse Search and Rescue

The strategy for a collapse search-and-rescue operation is as follows:

1. Secure the area;
2. Survey the collapse site; size-up the problem;
3. Shut off all utilities to prevent further injuries of victims and to protect rescuers;
4. Remove the surface victims;
5. Search voids created by the collapsed building structure;
6. Order all rescuers from the collapse pile and call a time-out; conduct a second safety inspection and confirm utility shut-off;
7. Perform selected-debris removal, hand-digging trenches and tunnels to buried victims;
8. Perform general-debris removal, clearing all debris from the entire area of collapse rubble.

Concealed Space Firefighting

The firefighting strategy to prevent fire from spreading in a common roof space is the same as the strategy for preventing an attic fire. Stop the fire in the concealed spaces from reaching the common roof space. The cockloft is fire service jargon used to define a common roof space, above a ceiling and below the underside of a roof. This common roof space is often present in garden-type apartments, row houses, strip malls, and large apartment buildings. The common roof space is usually the largest concealed space found in wood and ordinary-constructed buildings.

Fire often spreads to a common roof space by way of concealed spaces. Flames in a concealed space must be cut off before they get to the cockloft. The strategy is as follows: if a fire is discovered in the concealed space of a floor between the beams, open a wall where the floor beams meet the wall and the beam end rests on a bearing wall. If concealed fire is discovered in a wall between studs, open the ceiling above the wall studs; if fire is in the ceiling concealed space, check the floor above the ceiling fire. The strategy is to cut off the fire before it reaches the common roof space.

Defensive Firefighting Strategies

Protecting exposures, flanking a fire, and positioning apparatus in corner safe areas are defensive operating strategies. Ninety-five percent of the fires in the United States are extinguished by firefighters using an aggressive interior attack. Five percent of structure fires require a defensive strategy. Defensive firefighting should be employed in buildings with lightweight truss construction, in buildings with floors or roofs of unprotected lightweight steel bar joist, in steel prefabricated buildings, and in special-occupancy buildings, such as vacant buildings and buildings under construction or demolition.

Fire departments are well trained in offensive strategies, which are used successfully at 95% of the fires. Unfortunately, because defensive operating procedures are used less frequently, many chiefs, company officers, and firefighters are unfamiliar with their use and less effective in their use. Firefighter training should concentrate on defensive firefighting procedures.

Exterior Defensive Attack

A general rule for conducting exterior defensive attack that has been passed down from veteran chief to new chief states that if fire is on two or more floors and the hose lines are not making headway, an outside attack strategy should be considered. To quote from the Board of Inquiry report on the 23rd Street fire, where 12 FDNY firefighters were killed by a floor collapse,

> *It is our policy not to press interior attack once the fire extends beyond our immediate control or we are in doubt about the effects that the fire may have had on structural supports. All officers are instructed not to rely solely on the normal criteria for imminent collapse, such as cracks in walls sagging beams, or smoke issuing from mortar spaces, but rather to regard every building on fire as a potential hazard at all times.*

Firefighting Strategy

The steps of firefighting strategy at a row house or strip mall are as follows: Protect life with the first hose and sometimes a backup attack line. Prevent fire extension (downwind) with the second hose line. Confine the fire (upwind) with the third line. If the rear of the building is spreading fire, stretch a line to this location. Extinguish the fire with all lines confining the fire. Perform salvage and overhaul after the fire is extinguished. At most fires, the first attack hose team stretching one hose line extinguishes the fire and performs all five firefighting strategies simultaneously.

Flanking a Fire

A firefighting flanking strategy should be used in the following instances. When a wall appears to be unstable and in danger of collapse, set up master streams in a flanking position in front of the walls of adjoining buildings. If there is the danger of an explosion, position hose lines in a flanking position away from the doorway. When operating at a fast-moving windblown wildfire, position firefighters in a flanking position on each side of the advancing fire. At a fire in a high-rise office building, with a center core design, when the first attack hose line is unable to advance in on the fire, because wind blowing through a broken window pushes fire into the path of the advancing firefighters, a second line is the flanking attack hose line.

Frontal Attack

Frontal attack describes firefighters advancing an attack hose line inside a burning building toward a fire. Firefighters advance a hose line directly into the path of the raging fire. Firefighters using a frontal attack strategy confront the fire, heat, and smoke head-on. The firefighting strategy used by most fire departments throughout the country is an interior attack using a small-diameter hose stream. This strategy extinguishes all content and some structure fires in a building.

Group Think

Group think is a mode of thinking found in cohesive, highly disciplined teams. Group think occurs when the group strives for unanimity in action and when all member of the group concur with the objectives they are striving to accomplish. Most highly disciplined organizations, like the fire service and the U.S. military, demonstrate this type of thinking during emergency operations.

This mind-set has both good and bad effects. At most (99%) emergency operations, group think in the fire service is good. It helps us to accomplish objectives during dangerous emergency conditions efficiently. To be successful, all members of the fire service must understand and work toward the same objectives. Nevertheless, in some rare (1%) instances, group think can be deadly. Group think can have negative results when firefighters, striving for unanimity of action, let it override a realistic awareness of the situation. In this instance, group think may stop us from considering an alternative course of action.

Hose Line Placement

Hose line placement is the most important action in a firefighting operation. Most fires in the United States are extinguished by the first attack hose line. The first attack hose line should be stretched through the front, rear, or side door and drive the flames and heat to the outside through a window, doorway, or other ventilation portal. The second hose line usually back ups the first attack hose team unless there is a serious exposure problem. The second hose line backs up the first line for the following reasons: to protect the firefighter operating the first line in case of flashover, explosion, or collapse; in case the first hose line suffers a burst length of hose; and in case there is too much fire for one hose stream to extinguish. Furthermore, this hose line can be repositioned to the attic or floor above the fire.

Interior Defensive Attack

This is sometimes called a controlled-burn firefighting strategy. This is the strategy when an interior defensive hose line is operated by firefighters in a stairway enclosure for an extended period. The hose line keeps the fire from entering the stair enclosure. Smoke may enter the stairway, but fire will not be allowed to spread up the stairway. This strategy gives firefighters time to make aerial ladder rescues and searches of the upper floor from other stairways. An interior defensive operation can only be carried out when the stability of the building is assured. When the building stability is in question, an outside defensive attack or a nonattack strategy is more effective.

In fire department jargon, jumpers refers to people who have jumped from windows to avoid the flame heat inside a burning building. People sometimes jump from rear windows that do not have access for firefighters' ladder and rope rescues. Before leaving the scene of a residence fire, an incident commander should order an examination of all interior light and air shafts and the entire perimeter of the building, where occupants could have jumped.

"Kiss": Keep-It-Simple Strategy

Emergency operations are standard operating procedures. All firefighters at the scene of a fire or an emergency should know what the other firefighters are going to do. Do not complicate the firefighting. Fires spread the same way over and over; buildings collapse the same way over and over; and firefighting tactics should be performed the same way over and over.

Locating a fire is one of the most important size-up duties of the first-arriving company officer and chiefs. This information—fire location—lays the foundation for the entire operation. First, the location of the fire determines the number of firefighters and the amount of equipment needed to the control the blaze. Next, until the fire location is known, a fire officer cannot determine the overall life hazard. Finally, and most important, the point of hose attack and the method of venting the heat and smoke from the fire cannot be executed until the fire location is determined.

Master Stream Strategies

There are two strategies for master stream use. One is a temporary knockdown of a large body of flames. During this strategy, interior firefighters are withdrawn during the master stream use and then reenter to continue interior firefighting when the master stream is shut down. The second master stream strategy is a long-duration exterior attack in which master streams are used during the entire operation. In this strategy, firefighter are withdrawn completely from the burning building and must operate outside a collapse danger zone.

Nonattack strategy is used when there is a serious fire in a structure and people are descending a stairway. Instead of opening the door to attack the fire with a hose line, when the stairway is crowded with people descending past the fire, the door is kept closed, and the hose team does not attack the fire. In this instance, the fire officer keeps the door shut until all people have been taken below the fire. Then, the door is opened, and the fire is attacked. Also, a nonattack firefighting strategy is used when a serious fire is beyond the control of firefighters' hose streams and people are being evacuated from the floors above in a high-rise structure.

The nonattack strategy was used at the World Trade Center terrorist attack and fire on 9/11. The incident commanders, realizing that the fire was too great for manual firefighting, sent some firefighters into the high-rise towers equipped with masks and tools and ordered to perform search and rescue of trapped victims.

Overhauling

Overhauling strategy is as follows: conduct a collapse danger survey, use fans to remove toxic smoke, set up lights, shut off utilities, assign firefighters to specific areas large enough to avoid injury, start overhauling at the room of fire origin and work outward, and use a thermal-imaging camera to locate hot spots and avoid excess damage. Overhauling and salvage work are designed to save property and prevent a rekindle of a fire, after the department leaves the scene. From a health hazard point of view, overhauling is one of most dangerous stages of a fire. Solid particles of dust and smoke are inhaled when masks are not used during overhauling.

Priorities of Firefighting Strategy

The priorities of firefighting strategy, on the basis of which all firefighting decisions can be made, are as follows: Protect life first; this includes the lives of firefighters. Incident stabilization is the second priority of firefighting. Property protection is the third and last priority of firefighting.

Quenching, Venting, and Flanking

There are three strategies that firefighters can use for protection against backdraft smoke explosions. They are quenching, venting, and flanking. Directing a hose stream through a doorway or window into a room containing a possibly explosive atmosphere is referred to as quenching. The water stream directed into the explosive smoke and heat atmosphere may interrupt (quench) a developing explosion. When a door or window appears to have an explosive atmosphere developing, by directing a hose stream into the superheated smoke, you may break up the explosive atmosphere and prevent an explosion.

Venting roof skylights and scuttle covers can act as a relief valve for an explosive atmosphere. If these roof openings are vented and an explosion occurs, part of the blast will be diverted out these roof openings.

Flanking is a safe operating procedure firefighters can use when there is the danger that an explosion will blow out of a doorway or a window opening. When flanking a door, firefighters position themselves on each side of the doorway, away from any potential blast or shock waves that may come through the doorway. Hose streams operating in a flanking position at a doorway should be operated at angles that allow the water stream to enter the doorway and keep firefighters out of the path of any blast that may come out of the doorway or window of the burning store.

System Analysis

A system analysis is a method of analyzing the problems indigenous to structural firefighting. Any one of the parts (problems) of the system can disrupt a firefighting operation. The 13-point size-up used by some in the fire service is a systematic analysis of firefighting. A system analysis of a structure fire includes the following: size and location of the fire, construction of the fire building, the occupancy of the burning building, the area of the building, the height of the burning building, the life hazard, the adjacent exposed buildings, the apparatus on scene, the personnel who responded with the apparatus, the water supply, the auxiliary appliances available for use, the time of the fire occurrence, and the weather conditions.

Tactics

Firefighting tactics are defined as operations of fire companies at a fire or emergency. The fire company's tactics achieve the fire ground commander's strategies. Strategy is defined as the planning and directing of the fire ground commander to control the incident.

Utilities Shut-off

The fire ground commander should order the following utility control during a fire or emergency:

- Firefighters should shut off gas and electric before overhauling, which involves opening up plasterboard walls and/or ceilings.
- When there is a structural collapse or an explosion, gas, electric, and water supply to the building should be shut off to protect people trapped and rescuers.
- Electric supply to a building should be immediately shut off when it is the heat source of the fire or when a person is trapped by electric wire. Electric supply should be left on during a fire to provide visibility for searching, to provide power for elevators and sprinklers pumps.

Venting

There are four strategies for venting during a structure fire. They are:

1. Vent for life, by opening the roof scuttle over a stairway;
2. Vent for fire extinguishment, by venting windows opposite from where a hose team is advancing;
3. Vent to prevent horizontal fire extension when fire has spread to a roof space, by cutting an opening in a roof with a saw;
4. Vent to prevent an explosion when firefighters open a skylight over a store before the advance of the first attack hose line.

Withdrawal

There should be a prearranged signal for withdrawal of firefighters. This signal may be an electronic signal on a portable radio or an audible signal from apparatus. Four blasts on the apparatus air horn or a continuous sounding of sirens is a common emergency withdrawal signal used by many fire departments. All firefighters should be trained to leave equipment and leave a building when the withdrawal signal is heard. The use of the term Mayday over the radio is not effective as an emergency withdrawal signal.

×-Marking of Vacant Buildings

A strategy to warn firefighters of dangers in vacant building is ×-marking. A vacant building can be marked by drawing a box 12 inches square near the entrance door, using a fluorescent paint so that the mark is visible at night. One diagonal line drawn inside the box from one corner of the box to another indicates that there is a firefighter hazard in the vacant building. Two diagonal lines, forming an × inside the 12-inch box, indicates that there are multiple hazards in the building, and an exterior defensive firefighting operation should be considered.

Yard Hydrant System

A yard hydrant system's equipment—consisting of hydrants, hose, nozzles, and monitor deck guns installed in industrial plants, oil depots, lumberyards, and large factories—is not designed for initial use by firefighters. Yard hydrant systems are designed for use by a private fire brigade. Firefighters may take over the hose lines and monitor nozzles being used by members of a fire brigade on arrival. However, if members of a fire brigade are not present, firefighters should not depend on the yard hydrant system. The arriving firefighters should stretch their own hose and pumper and use the public water supply, not the private yard hydrant system.

Zones of Danger

A collapse zone is the distance firefighters should be kept away from a wall that appears in danger of collapse. A collapse zone should be a distance away from the wall at least equal to the height of the wall. An explosion danger zone should be established whenever there are high or low explosives or a blasting agent that might explode. When there is a danger of blast caused by an explosive mixture, all bystanders and firefighters should withdraw a distance of 2,000 feet. When there is the danger that a propane tanker truck might explode (i.e., a BLEVE [boiling liquid expanding vapor explosion]), firefighters should withdraw a distance of 800 feet.

34 MYTHS AND MISCONCEPTIONS

There are many myths about firefighting strategy. An incident commander must study the craft of firefighting and know what information is fact and what is a myth or misconception. The fire service is a traditional organization and passes information from one generation to another. Most of the information is accurate and saves lives, but some of the information is incorrect. The following are myths and misconceptions about firefighting strategy and tactics.

Fig. 34–1. If there is one word synonymous with incident commander it is communicator. An incident commander must be a good communicator.

1. ***The best fire strategists in the service are the strong, silent types, those who do not issue too many orders.***

Don't believe it. The most important skill of a fire officer is the ability to listen and communicate (fig. 34–1). As a supervisor, you must communicate. At fires and emergencies, chiefs and company officers must give orders and say clearly what they want accomplished. At some fires, you must receive and transmit messages over portable radios and tune out unbearable noise and horrible sights—in freezing weather, when soaking wet. During an emergency, you must make life-and-death decisions without all the necessary information. Thus, you must get and transmit as much of the information that you have. You must know how to communicate—that means listen and talk.

Everyone must get as much information as you can before, during, and after making a decision. If you do not receive necessary radio reports from firefighters and company officers inside a burning building, you must request it.

You must ask the right questions and get the most complete answers you can get. The key to life-or-death decision making is the ability to ask questions, listen to answers, and then say what you want accomplished.

2. ***Never use an opposing-hose-lines strategy where firefighters may operate hose streams against each other.***

This may have been true years ago, before fire officers had portable radios that gave us the ability to coordinate and control fire companies at a fire. In the 1960s, having hose teams positioned at opposite sides of a building often resulted in hose streams being directed against each other, injuring firefighters and delaying the extinguishment of fire. Today, you can position hose teams at opposite sides of a burning building or a fire area and coordinate their actions with the use of radio communications. As the first hose team advances from the front of a building, the hose team at the rear can be ordered to protect exposures and not direct the hose stream into the path of the advancing first hose team. However, if the first hose team cannot advance owing to heat, fire, or wind, the incident commander, using portable radios, can order the first team to back out and close the door. When assured that this has been done, the commander may order the second hose team at the rear to advance on the fire. Having hose teams positioned in opposite positions actually gives the incident commander two avenues to attack a fire. It can be a safety backup. Still, the two hose teams must be controlled and coordinated by the incident commander and must not direct hose streams at each other.

3. ***During a fire, you can always depend on the incident commander to tell you when to withdraw if there is a danger of collapse.***

Don't believe it. The chief standing at the command post cannot see inside the burning building. He or she cannot see the roof conditions or know about the stability of the rear wall of a burning building. Actually, the incident commander standing at the command post is expecting you to tell him or her of any collapse danger. The incident commander expects the fire officers working inside, on the roof, or at the rear of the burning building to relay reports of any danger requiring safety precautions. The firefighters in and around the burning building are the eyes and ears of the chief. Firefighting is a team effort. After receiving information advising of a collapse danger, the incident commander can issue orders to safeguard all firefighters at the scene: firefighters inside the burning building, on the roof, and at the rear.

4. ***It is best not to use a proactive strategy to call resources to a fire because you may look foolish and transmit an unnecessary greater alarm.***

He who hesitates is lost. An incident commander should transmit the alarm or call the mutual aid companies as soon as the need exists, even if they are not used at the fire but just stand by ready for action. It is best to have reserve forces at a fire or emergency. At a serious working fire, there should be one engine, one ladder company, and one ambulance standing by at the scene. This is in addition to the RIT.

Decision makers use the term being proactive. Your emergency decision making should be proactive; it should not be reactive. Remember that most firefighters are sitting in the firehouse listening to the radio reports of the fire and want to respond. They want to get the experience. Moreover, you want to get the experience of handling a large number of personnel. I have been in command of fires where I had too many firefighters at the scene, and I have been in command at fires where I had too few firefighters. Believe me, having too many firefighters makes you feel much better. Also, the former situation gives you the most confidence and helps you make better decisions. You can always use fresh firefighters during the salvage and overhauling stage and send exhausted firefighters back to quarters. In making any decision, it is better to make an error of commission than omission.

5. ***Experience is the best teacher of firefighting strategy. Book learning is not as good as learning by experience.***

This is true, but it can't be done. You must get experience from both actually doing the job and reading books on how to do the job. You can't possibly get all your knowledge by experience. You must read and learn from books, fire service magazines, and department firefighting procedures.

Another point about learning in the fire service is that you will never feel that you have enough experience. When I was a rookie, I thought that when I became first grade, I would know enough to "feel" experienced. It did not happen, and when I became first grade, I believed that once I had 10 years in the fire service, surely I would feel like a veteran. Nope. It even became more complicated because I was promoted to the rank of lieutenant, and I became a rookie fire officer. When I left the fire service as a "veteran" chief, after 42 years, I still I didn't know enough. I was still trying to know more about the fire service by experience and book learning. What I did finally realize at this time was that when you think you know enough about firefighting, you had better retire, because you are going to kill yourself or somebody you work with. Keep learning from experience and from books; it is best to feel you do not know enough about firefighting in order to survive.

6. ***The only size-up of a fire required is a close-up size-up conducted by fire officers inside the burning building.***

This is a half-truth. At most fires, the inside size-up is the most important, and it is the most accurate size-up. You cannot see much standing outside a burning building at the command post. At most fires, the chief usually requests a size-up report from the officer inside the burning building, which is close to the fire. This is the best size-up at most fires. However, the real truth is that this is the best size-up only when the fire is confined to one floor.

If a fire spreads to the common roof space or if the fire has quickly spread to several floors above the original fire floor, the inside size-up becomes less accurate. The firefighters inside see the fire only on their floor. They cannot see the flames in the roof cockloft or the fire on the floors above them. When the fire has spread to the roof space or several floors above in a building, then a size-up from outside the building is more accurate than the size-up conducted from inside.

In summary, the best size-up of a fire confined to one floor is from inside. When a fire involves a floor and the roof or several floors, the outside size-up from the command post is more accurate. At every serious fire, you should have an operations officer perform the inside size-up and the incident commander outside perform the outside size-up.

7. ***Firefighters can escape death from a collapsing wall by outrunning it or by jumping into a doorway.***

These are deadly myths. Firefighters can't outrun a collapsing wall. It's too late already when you hear the shout, "Watch out!" The wall is on top of you.

As far as jumping into a doorway to escape a falling wall goes, this is also untrue. Yes, there have been collapses where walls have fallen outward and firefighters standing in front of a door or window opening have miraculously survived. But what actually happened was sheer luck. They were standing in a spot where there was an opening. And the falling wall passed around them. They did not jump into the doorway or move to escape. A professional fire department does not recommend miraculous escapes as a substitute for safe fire ground procedures.

When a wall is in danger of collapse, incident commanders should order a defensive strategy. Order firefighters to withdraw beyond the established collapse zone. Moreover, if a roof causes a secondary wall collapse, pushing it outward, and a firefighter jumps into the doorway to escape the falling wall, he or she may be crushed to death by the roof collapse.

8. ***Defensive firefighting strategy outside a burning building is not dangerous.***

This is false. Operating outside a burning building is still dangerous. Operating outside and around the perimeter of a burning building can be just as dangerous as working inside a burning building. Outside a burning building, walls collapse on firefighters; explosions blow out windows, doors, and walls; falling glass, chimneys, marquees, cornices, and canopies descend on firefighters. Even people jumping out windows fall on firefighters. All these dangers kill and injure firefighters outside a burning building.

The perimeter around the outside of a burning building is a deadly area. Some incident commanders erroneously believe that operating outside a burning building is not as dangerous as operating inside a burning building. Firefighters killed and injured "by wall" are operating outside a burning building. Firefighters operating outside buildings have been killed by collapsing marquees, canopies that cave in on top of them, parapet walls that crash down on top of them, and burning cornices that peel off building facades like deadly waves. All of these collapses kill firefighters operating outside the burning building.

9. ***An aerial master stream should not have the stream directed at flames from above coming through the roof. The best strategy is to let the fire vent itself.***

This is true sometimes. Other times, it is not. I learned a lesson one night at a multiple-alarm fire in a row of stores in a large shopping mall. On my arrival, the battalion chief had an aerial master stream operating from above, into a store where the flames had burned through the roof. Believing it was ineffective, I changed the strategy. I directed the aerial streams shut down, lowered, and repositioned to operate into the windows and doors around the store. I reasoned by allowing the heat and flames to self-vent by flowing through the roof, I could sweep the fire, knock down the blaze more quickly, then move the hand lines into the stores.

After the strategy change, I received the following progress reports from sector officers around the fire. First, from fire officers operating in a nearby four-story residential building, I received a report that smoke from the roof fire was spreading into the building, requiring the evacuation of occupants. I ordered the windows closed and the building evacuated. Next, I saw a flying-brand problem developing. A firestorm of burning embers from the store fire began to blow onto the rooftops of several nearby buildings. I directed several fire companies to perform brand patrol. Then, I surveyed the fire ground and saw that my strategy of extinguishing the fire with streams directed into windows below the roof had placed firefighting companies and aerial platform buckets under a dangerous-looking parapet wall that might collapse. That's when I changed the strategy back to the battalion chief's original strategy.

That night I learned a lesson. Sometimes it is good strategy to operate aerial ladder streams or hose lines from an above, directed at flames burning through a roof. At this fire, after I changed the aerial master streams to direct streams into the burning store from above, it stopped the smoke from going into the residence building. It stopped the flying brands, and I improved fire ground safety by backing the firefighters away from the dangerous parapet wall.

In defense of directing master streams into windows from below instead of from above, this strategy can be effective if the store is one large area and there is a large window area in which to maneuver the stream. Provided that the wall is not in danger of collapse, an aerial master stream directed into the store window openings can be very effective and quickly knock down a fire. However, at this fire, there were several stores subdivided by partitions blocking the streams' effectiveness. When there are many partitions, you cannot sweep the master stream throughout the entire area. Fire burning in concealed partitions cannot be extinguished. Directing master streams from above in a surround-and-drown operation with master streams may not be very effective at extinguishing fire quickly, but it is a safe surround-and-drown operation.

10. ***A fire in a vacant building is not a dangerous fire.***

Some incident commanders do not believe that a fire in a vacant building is as dangerous as a fire in an occupied building. This is wrong. A vacant building fire is more dangerous than a fire in an occupied building. Some dangers inside a vacant building that kill and injure firefighter that are not usually found in occupied buildings are:

- Holes in floors—particularly in entrances to buildings in hallways
- Missing treads and landings in stairways
- Absence of doors and windows, allowing rapid fire spread and trapping firefighters
- No electricity for lights, making entry and search hazardous
- Boarded-up windows and doors, making the venting of smoke from the building more difficult

Beware of the vacant building.

11. ***Firefighter safety is not the responsibility of the incident commander. Firefighters are paid for the risks of firefighting.***

This used to be true, but it is no longer. The incident commander is accountable for the safety of all firefighters at the scene.

The safety of firefighters is considered highest priority. Firefighter safety is just as important as citizen safety. Firefighters experience dangers every time they respond to fires and emergencies and when entering burning buildings to search for victims and the fire location. Incident commanders do not expose firefighters to unusual dangers; the nature of the emergency work exposes the firefighters to danger. The highest priority of firefighting is life safety, and this includes the lives of firefighters. Incident stabilization is the second priority of emergency work, and property protection is the third priority. These priorities are the principles of all firefighting strategy decision making.

12. ***The most dangerous operation at a fire in a truss roof building is roof venting because this firefighter may fall through the roof.***

This is not true. The greatest danger of truss roof collapse is to firefighters working below the truss roof. Fatal fire records show that more firefighters are killed each year by truss roofs collapsing on top of them. Of the last 17 firefighters killed by lightweight truss roofs, 16 were operating hose lines or searching inside the burning building when the roof caved in on top of them. Only one of the 17 fell through the collapsing truss roof. Training videos show firefighters falling through the roof. There are no training videos showing firefighters inside the building when the burning truss collapses on them and traps them in flame.

Also, the National Fire Protection Association conducted a 10-year study of structural collapse. Fifty-four firefighters died in collapses during a 10-year period, from 1991 to 2000. Twenty-one died in floor collapses, 19 died in roof collapses, 12 died in wall collapses, and 2 died in a ceiling collapse. Of the 19 firefighters who died in roof collapses, 15 were killed inside the building, operating below the collapsing roof, and 4 were operating above the roof when it collapsed. Thus, operating inside a burning building, below a truss or any type of roof, is more deadly than operating on top of the roof.

13. ***Most firefighters die fighting fire in residential structures, so a strategy of interior firefighting in residence building fires presents the highest risk.***

This statement is half true. Most firefighters do die fighting fires in residential buildings. However, this is because there are more fires occurring in residence buildings, not because this type of occupancy is more dangerous. When you look at the rate of firefighter death per fire, you get a better idea of which occupancy is more dangerous. In residential buildings, 4 firefighters die for every 100,000 fires. Stores and office building fires are more dangerous to firefighters than residence building fires; in stores and office buildings, 9 firefighters die for every 100,000 fires. Burning vacant buildings and buildings under construction or demolition are even more dangerous; 12 firefighters die for every 100,000 fires that occur in vacant buildings and in buildings under construction or demolitions. A defensive firefighting strategy should be used more often at fires in special occupancies and commercial occupancies.

14. ***The incident commander is totally accountable for the safety of all firefighters at a fire.***

The incident commander has the ultimate responsibility for the safety of all firefighters at a fire. However, sector officers are also responsible for firefighters operating in their sector, and company officers are responsible for safety of firefighters in their companies. Even firefighters must take responsibility for their own actions.

Firefighter safety is a team responsibility, not the responsibility of one officer standing outside, at the command post. The legal and moral responsibility of the incident commander for firefighter safety is shared by sector officers and company officers. For example, if you have firefighters who are freelancing, company officers who do not have control over the firefighters in their command, and sector officers who do not understand that they are responsible for the safety of fire companies in their sector, then the incident commander is not going to be effective.

15. *Speed is most important when responding to a fire.*

This is a prevalent misconception in the fire service. Speed is never as important in emergency response as is dependability. Dependability of arriving at the scene and controlling the fire or emergency has always been the hallmark of the fire service, not how fast you do it. As a citizen, when I call for a fire company, I want to know that you will arrive at the scene to help me 100% of the time. A quick response is important, but dependability of arrival is much more critical. If you speed to a scene, get into an accident, and do not arrive at the emergency, then you have failed. One of the reasons fire departments dispatch several of the same type of units to the scene of an emergency is to ensure dependability of arrival. One of the reasons citizens call the fire company instead of other emergency services is our dependability.

35 POSTFIRE INVESTIGATIONS

The first thing I noticed when becoming an officer in the FDNY was that firefighters would ask me questions. As a firefighter, no one had asked me questions. In fact, when offering my opinion as a rookie, some officers told me to be quiet. However, once I was promoted to lieutenant, a lot of people thought that I had answers. It was not just me; my friend, who was promoted with me, said the same thing.

Being a pretty good student of firefighting and after gaining some firefighting experience, I realized that I did know some answers. It seemed that I knew more answers than most others. And when asked a question for which I did not know the answer, I knew where to find it: I knew a fire officer or chief who knew the answer, so the next time I would be able to answer the question.

After moving up the ranks, the questions increased in frequency and complexity, and they often were about firefighting strategy. I actually learned a lot from the questions asked during fires. Some of the best questions at fires came from firefighters during the height of a blaze. Many questions were really hidden suggestions offered by veterans to a rookie fire officer: “Chief, do you want me to set up some lights on the building?” “Chief, I am not doing anything with this tower stream. Should I shut it down?” “Chief, I think we could use a second line up here.” “Chief, do you want a portable ladder placed at the window where the guys are operating?” I realized that suggestions in the form of questions are really helpful. They help your firefighting strategy. They make you think. Questions with suggestions (answers) are the best. Keep those questions coming!

The following are 10 questions about firefighting strategy asked at fires. These same 10 questions are also asked after a fire has been extinguished. And they must be answered during a postfire investigation.

1. Where does the first hose line go?

For a room and/or content fire in a house or apartment, the first attack hose line is stretched by firefighters through a front, rear, or side doorway, and the fire is extinguished. The hose stream nozzle is positioned and is used to drive heat, flames, and smoke from inside to outside through a vented window, a doorway, or an opening created by outside vent firefighters.

The first attack hose stream is usually not directed into a flaming window. One of the advantages of advancing the first attack hose line through a doorway, rather than directing it through a window, is that unconscious, trapped victims are often found in the doorway or in the hallway, between the doorway and the fire. An analysis of fire victims trapped and killed in burning buildings revealed that most fire victims are discovered near the fire area. The next location in which fire victims are discovered is in hallways or corridors leading to an exit. They were trying to escape the flames and were rendered unconscious by smoke, heat, or toxic gases in the path to the door. Firefighters advancing the first attack line through a doorway often come across these victims on the way to extinguishing the fire (fig. 35–1).

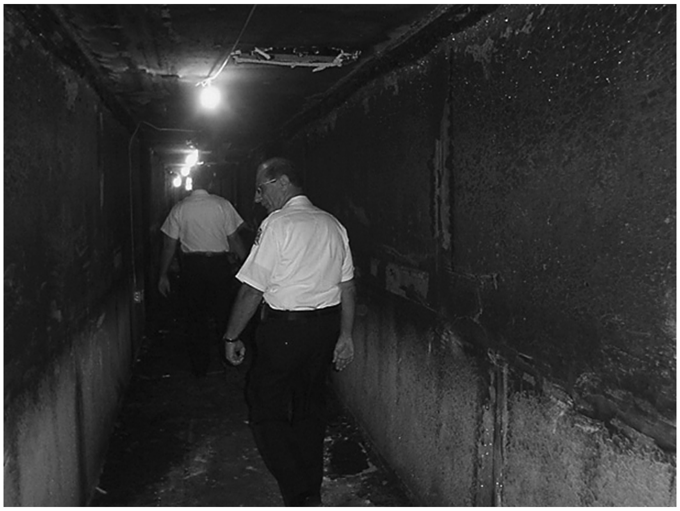

Fig. 35–1. When conducting a postfire investigation, the officer should ask where the first attack hose line was deployed.

2. Where does the second hose line go?

If there is an exposure problem, such as flames spreading to a nearby structure, the second hose line goes there; flames coming out a window are not an exposure problem if there is no nearby building. At most building fires, there are no visible outside exposures. The exposure problem is most often an inside exposure. The second hose line stretched follows the path of the first line up the interior stairway or to the side or rear entrance. The advantages of having a backup hose line stretched into the burning building right behind the first line are as follows:

- This is a safety action to protect firefighters operating the first attack hose line in case of flashover, explosion, collapse, or a radio Mayday transmission, indicating that a firefighter is trapped.
- If the first hose suffers a burst length or a broken nozzle, the second hose team can move into position and attack the blaze.
- If there is too much fire for one hose attack team to extinguish, two hose lines working side by side may be successful.
- If there is no need for the second hose line and the first hose attack team can handle the room-and-content fire, it is important to get the second hose line up to the floor above, the attic, or an adjoining room to cut off spreading fire.

3. Where should I place a portable ladder?

Portable ladders are most often raised and placed at fires in 2½-story private dwellings. If there is a person trapped at a window, the portable ladder is placed directly below the window, and the firefighter climbs it for a rescue. Often there is no visible life hazard. In this case, a portable ladder is raised to the second floor window at the B or D side of the house. This target window is the opening at the top of the stair landing. The purpose of this ladder is to allow an outside vent firefighter to vent the second-floor window at the top of the stairway and relieve smoke buildup in the second-floor bedrooms. Also, this ladder may be a lifesaver for a searching firefighter who needs to escape out the window in case of a flashover or flame cutting off retreat down to the first floor.

Another part of a 2½-story residence where a portable ladder is positioned is at the front porch roof. This ladder is placed to allow firefighters to operate from the porch roof. From here, firefighters may enter the second floor through a window for an interior search. If the heat and smoke conditions inside the second-floor bedroom off the porch are severe, firefighters may vent windows from the porch roof.

4. Where do I vent the fire?

If the location of the fire is known, a firefighter is assigned the duty of outside vent firefighter and will assist the advance of the first attack hose line by window venting. If the fire is at the second floor, a portable ladder should be placed at the side of the window, and a firefighter with a pike pole coordinates window venting of the burning room with the advance of the attack hose team.

At a burning strip mall, the firefighter assigned to the roof, if roof stability allows, should immediately locate the store with the fire and vent all the roof skylights and scuttle covers that serve the smoke- and heat-filled store. If fire is burning in the common roof space over the store, cut and pull the roof deck as close as possible over the fire and push down the ceiling. This store roof vent cut is designed to prevent horizontal fire spread in the common roof space to adjoining stores.

Next, the rear doors serving the burning store should be vented. The advancing hose team will be able to push heat and smoke out the vent openings of the roof skylight and open rear doors. This venting will lessen the chance that the hose team firefighters will be scalded or burned from a heat buildup.

The large front glass windows of a burning store are vented when the hose team starts their advance into the store. After the hose lines are charged with water and firefighters are in full protective equipment, the front store glass door or window is broken. The hose team should be safely out of the path of any potential initial explosive blast when the front store windows are vented.

Venting at a multiple-dwelling building should be conducted on the roof and the windows of the fire apartment. On the roof, the scuttle cover or skylight over the interior stairs must be immediately vented. This will prevent smoke and heat buildup in the top-floor apartments. If the fire is on the top floor and the apartment has a skylight, this too should be vented.

Window venting of the fire apartment at the rear will have to be accomplished by a firefighter operating from a fire escape or leaning over from the roof. Windows at the front of the building can be reached and vented with a ladder.

5. Where should I position the aerial ladder?

The aerial ladder should be positioned so as to allow rescue of any person trapped in a burning building. A person in danger trapped at a window, out of reach of a portable ladder or interior searching firefighter, should be the first consideration when positioning an aerial ladder. If there are no victims trapped at the windows and there is a possibility that a firefighter may be trapped and appear at a window, the aerial ladder can be positioned so as to anticipate this possibility. If there is no likelihood that occupants or firefighters will need an aerial ladder rescue and there is the possibility that the fire strategy will change from offensive to defensive, the incident commander should order the chauffeur to position the aerial ladder for possible aerial master stream use. An incident commander should be proactive and order the chauffeur to position the ladder in the front, side, or rear of the burning building for possible use. In some instances, an incident commander may order a large-diameter hose stretched to a location in anticipation of the aerial ladder's arrival. An aerial ladder is usually positioned at the downwind side of the fire at a corner position. An aerial ladder should be positioned at the AB or AD side of the burning building for possible future operation with a master stream.

6. *Where do I start to search?*

The primary search should start in the area of fire origin. For example, if the fire starts on the second floor of a building, the primary search starts in the room of fire origin and then moves outward toward the exits, such as a window, door, or fire escape. People often attempt to flee a fire and crawl to an exit. They sometimes do not make it, and their bodies are found in the path to the exit. After the fire origin and pathways to exits are searched, all adjoining bedrooms in the apartment are searched, especially during a night fire. After the entire fire floor has been covered, including bathroom closets and behind and beneath furniture, the search is expanded. The floors above and the attic are searched next, since heat and toxic gases rise.

After the primary search is complete, a secondary search is conducted. This more-thorough search includes every possible place a victim could be. Victims are sometimes found lying on the stairs and in rooms or apartments directly above the fire. In a multistory residence, all the living areas on the floors above must be included in the secondary search, even if the fire is on a lower floor or in the cellar. Smoke, heat, and gases from the fire anywhere in the building will rise up open stairways and mushroom out on the top floor. The top floor and the attic are where fire victims some distance from the lower-floor fire may be found. The searching firefighter should follow the smoke.

An important aspect of conducting a secondary search is to question occupants or neighbors to see if they know if all persons are accounted for. A secondary search must always be thorough; the questioning of occupants who escaped the fire and neighbors should not be omitted. If the burning building is a motel or a lodging house where transient people stay, after the interior is searched all areas outside, around a building must be searched for people who might have jumped from windows.

7. *Where could the fire spread inside the building?*

The first place fire is going to spread is into the ceiling concealed space directly above the fire. Heat rises, so as soon as the flames are extinguished, have a firefighter open up the ceiling directly above the fire with a pike pole. Heat sometimes is conducted through a plasterboard ceiling and starts a fire in the concealed spaces between the ceiling beams. Therefore, the incident commander should immediately open up the ceiling above the fire. If the content burning in the room is near a wall, open up the plasterboard wall near the content fire with a pike pole next. Sometimes the heat is conducted through the walls into the concealed space between the wall studs.

When you start to open up plaster walls, first use a thermal-imaging camera if available; this will reduce damage by pinpointing exactly where the fire has spread in the concealed spaces. If there is no camera, after the ceiling above the fire has been opened up with a pike pole, make a small hole in the ceiling and the wall near poke-through holes in the plasterboard. First, make a small hole with the pike pole around any ceiling eclectic light fixture, and then open up around radiator pipe recesses. Then, check any electric wall opening for heat with your hand. If it is too hot to touch, open up the wall. If fire is found in any concealed space, try to cut it off before it spreads further. For example, if fire is found to be spreading in a floor, follow the space between floor beams and open up near a wall. Wet this cutting edge of fire with a hose stream. If fire is in the wall, open up the ceiling above and wet this area with a hose stream. If fire is found in the ceiling, follow the ceiling beams, open up the ceiling until there is no visible charring, and get someone up to the floor above to check for vertical fire spread. If the fire is in the wall concealed space, check the attic. Balloon construction will allow any fire in an outer wall space to spread to the attic. If fire spreads past the plasterboard wall, it could travel in the concealed spaces of walls, ceiling, and floors.

A building that has been renovated has more and larger concealed spaces. Fire may skip a floor and break out in remote locations when it enters a concealed space of a renovated building. Autoexposure, from a window on one floor to a window above or from a window to the eaves, is another form of fire spread that must always be checked. An incident commander must realize that you cannot cut off fire that has spread to floor and ceiling concealed spaces of a building with lightweight wood truss construction. This is because flames spread parallel between the beams and also perpendicular through the truss web members. Fire spread in floor and ceiling concealed spaces of a building constructed with lightweight wood construction is 100% faster than convention solid beam construction. Get the people out and use a defensive firefighting strategy.

8. Where is my exposure problem?

At a normal store or house fire, adjoining buildings over 30 feet away are relatively safe from fire spread. However, there are two exceptions: windblown burning embers could land on a roof up to a half-mile away from a fire; and radiated heat may spread fire across a 90-foot-wide street. Most fire spreads to exposures by convection currents of flames and heat. Flames leaping from a window usually spread fire to nearby buildings separated by narrow alleys. The flames need not come into direct contact with the nearby building. The radiated heat from the flames blowing out a window may be severe enough to ignite combustible siding on a nearby building.

If two buildings are an equal distance from the burning building, the exposure problem will be downwind. The wind will blow any burning embers mixed with the fire downwind, and if the smoke turns to flame, the flame will also be heading downwind; thus, protect the downwind exposure first. This is not to say that other nearby buildings need not be protected. The strategy of firefighting, after protecting life hazard, is to prevent fire extension. After you have protected the downwind building, protect the other sides around the burning building if needed.

After the downwind exposure has been protected, the following should be considered when stretching a hose line. If one building is closer to a fire building, this building should be protected. After this building has been protected, consider stretching a hose line into the tallest exposed building. After all the four exposures are protected with hose lines, you have the fire confined. Extinguishment is the next phase of the fire strategy.

9. ***What is the collapse danger?***

The common collapse dangers at a house fire are the ceiling, the chimney, truss construction, and the porch. The reoccurring collapse dangers at a burning strip mall are the parapet wall, a canopy or marquee attached to the parapet wall, a suspended ceiling, and the roof. Machinery may cause the roof beams to fail. Truss construction may make roof venting too dangerous. The common collapse dangers at row houses are the decorative cornice, apartment ceilings, and stairways overloaded with firefighters; in addition, there is the danger of total lean-over collapse, in which an entire corner row building collapses into the street.

10. ***What are the worst catastrophes that could happen at this fire, and what should the incident commander do if in case any of these happen?***

Flashover, explosion, collapse, and Mayday transmission are all catastrophes for which the incident commander should be prepared:

- Flashover. There are three defensive procedures that can reduce the risk of death and injury from flashover:
  - Use a hose stream to cool the fire. The discharge of a portable extinguisher can cool the heat down in a burning room temporarily and delay flashover. The discharge of a typical 1¾-inch hose stream into a smoke- and heat-filled room can completely stop a flashover.
  - Vent the fire. By venting windows of a burning room, you release smoke and heat in the room. This slows down the buildup of heat that is necessary for flashover to occur, in addition to improving visibility in a smoke-filled room.
  - Delay venting of the fire. At some fires, by not venting and instead having firefighters close the door to the burning room, you can delay flashover. By not venting, you starve the fire of oxygen, which slows down the combustion rate, which in turn slows down the buildup of heat in the room. This may be done when there is a delay in stretching a hose line and all persons are out of the burning room.
- Explosion. There are three strategies that an incident commander can use when there is a danger of explosion:
  - Venting a roof skylight over a burning store is one of the most effective methods of protecting firefighters from a natural gas blast or a smoke explosion (backdraft). When roof conditions permit, the quick removal of a glass skylight by firefighters can vent a smoke-filled store and break up an explosive mixture. The rear of the building should be vented as well. Even if the explosion occurs, the blast will be diverted upward out of the roof vent opening or through the rear doorways and windows, away from the firefighters advancing the hose line.
  - Quenching the superheated confined fire area is another strategy that an incident commander can use when there is a danger of explosion. Before firefighters enter a doorway

  that appears in danger of exploding, a charged hose line should be positioned near the entrance flanking the doorway. Firefighters in full protective equipment should discharge a hose stream into a fire area when it is opened up. This water can cool a potentially explosive atmosphere. Before the searching firefighters enter a burning, confined, potentially explosive fire area, the stream of a powerful water discharge might break up the explosive atmosphere. This is not as effective as roof venting, but sometimes it is the only alternative.
  - Flanking can be used when there can be no venting, and quenching by quick use of a hose stream is not possible. The incident commander can protect firefighters from an explosion in some instances by flanking a doorway to a burning room with hose lines. The incident commander can order two hose lines into position, one on each side of a door or a window of a burning store that is suspected might explode. After the hose lines are charged with water and the firefighters are in full protective equipment, the front store glass door or window is broken. Both flanking hose lines, safely out of the path of any potential explosive blast coming from the opening, can be directed into the burning store.

- Collapse danger. There are three strategies that an incident commander can take when there is the danger of wall collapse:
  - Establish a collapse danger zone. Firefighters would not be allowed inside the collapse danger zone once it has been declared by the incident commander. The collapse zone is defined as the ground area that a falling wall will cover with bricks or other materials during a collapse. The collapse zone occupies the base of the unstable wall and extends out for a distance equal to the height of the wall. When a brick or wood wall collapses in a 90°-angle collapse, it will kill any firefighter operating near the wall within the collapse danger zone. For example, a 20-foot-high wall collapsing at a 90° angle will kill firefighters operating closer then 20 feet from the wall.
  - Flank the fire. This can be an effective strategy when a tall structure is involved with fire and there is danger of a wall collapse. At such a fire, the establishment of a collapse zone could require firefighters to be positioned so far away from the front of the building that the hose streams will not reach the fire. The reach of the average hose stream operated by firefighters is 50 feet. During a fire inside a church or heavy timber five-story mill building, for example, a collapse zone might require hose streams to be operated 70–80 feet from the burning building, to protect firefighters from a falling wall or explosion. Instead of establishing a collapse zone, a fire chief may order the firefighters to place hose streams in a flanking position. The chief would order the hose streams operated in front of the adjoining buildings, to each side of the burning building. The hose stream range and effectiveness will be reduced, but the life safety of the firefighters will be ensured, even if the unstable wall falls beyond the collapse danger zone.
  - Change to a defensive firefighting strategy. If there is the danger of floor,

roof, or wall collapse of a burning building, the incident commander can order a strategy change. Firefighters should be withdrawn and repositioned. One defensive strategy is to use an aerial stream operated by firefighters outside the collapse zone, with the stream directed from above the roof of a burning building. This may be less effective than if the aerial stream were directed into a window, but firefighters in the bucket at the tip of the ladder will be safely above the collapse zone of a weakened floor, roof, or wall. When there is no danger of wall collapse, firefighters may operate the aerial platform bucket nozzle close to the flaming windows of the building for effective penetration of the master stream. However, conducting a close-up attack should not supersede firefighter safety when there is a danger of collapse at a fire. The priorities of firefighting strategy are life safety first, including the lives of firefighters, and fire containment second.

- Transmission of a Mayday. At every working fire, an incident commander should have a rapid intervention team (RIT) standing by to rescue trapped, missing, or injured firefighters. An RIT helps a fire chief react to one of the worst emergencies that can happen on the fire ground—a missing or trapped firefighter. The RIT and the OSHA two-in/two-out rule are acknowledgments of the fact that sometimes the rescuer becomes a victim. A fire company or an RIT standing by at the command post must be ready at all times to start a search and rescue during the fire or emergency incident. The RIT should have masks, a search rope, and a rescue rope to allow a quick entry into a smoke-filled area. They should have or know where to obtain at a moment's notice a ladder, a chain saw, circular saws, and lights. The RIT should not leave the command post unless ordered by the command chief. The RIT should not be used for firefighting unless there is suddenly a life hazard, and then it must be replaced immediately, in case a firefighter becomes trapped or missing.

Fig. 35–2. The officer who conducts a postfire analysis learns more about fire strategy than the fire officer who was in command of the fire.

36 GLOSSARY

Access stairs: Open stairs between floors, allowed in some office buildings and in duplex apartments. Such unprotected stairways provide access to offices or apartments on different floors. Access stairs are a major avenue of fire spread. Any firefighter who discovers an open stairway during a fire must immediately report this to the incident commander.

Accountability system: Tags, riding lists, command computerized tracking system, electronic chips, or GPS devices. The accountability system is intended to help supervise the movements of everyone operating at the incident. Accountability prevents freelancing, which sometimes leads to unnecessary reports of missing or lost firefighters. However, chiefs, company officers, and firefighters must understand that you cannot delegate accountability to a system. Everyone has accountability. Everyone at a fire has a responsibility to be accountable. For example, the officer in command is ultimately accountability for all operations in the fire area. However, realistically, the incident commander can communicate with and supervise only the sector officers; the sector chiefs, chiefs, or company officers in charge of parts of a fire ground are accountable for companies in their sector; the company officer is accountable for firefighters in the company; and most important, each firefighter is accountable to the officer of the company.

Active fire protection: Fire protection provided by sprinklers and firefighters' hose streams.

Apartment house: Ordinary (type III) construction four to six stories in height and divided into two or more sections, or wings. The most common apartment house has two sections and is called an H-type apartment building. The living units are generally located in the sections or wings, and the elevators and a large entrance lobby are usually found in the center connecting part of the apartment house. This center connecting area of the apartment building is identified as the neck or the throat during firefighting radio communications. Apartment houses were first constructed during the 1920s and 1930s in inner-city areas and the surrounding suburbs.

Apse: Part of a church that is a semicircle or a U-shaped wall.

Attack stairway: The stairway used to attack the fire. Attack stairways should not be used for evacuation because they will be filled up with smoke and heat.

Autoexposure: The spread of flames on the outside of a building from one floor to the floor above. Flames can be sucked up to the floor above from window to window. Firefighters entering a window on the floor above a fire from a ladder or fire escape can have their escape path back to the window cut off by autoexposure flame spread.

Backdraft: An explosion caused by the rapid ignition of smoke and fire gases occurring in a tightly sealed burning room. The trigger for a backdraft explosion is the fresh air that enters during firefighters' initial search and entry. The fire produces combustion gases and high temperatures and, since little or no air flows into the sealed room, consumes most of the room's oxygen. When a door to the superheated room is opened, air is introduced and completes the fire triangle necessary for a sudden rapid explosion. Firefighters performing search-and-rescue operations are sometimes killed and injured by the blast of a backdraft.

Basement: A story that has half or more of its floor level above street level.

Blasting agent: An explosive material widely used for demolition. It consists primarily of ammonium nitrate and a fuel such as no. 2 fuel oil. The danger of a blasting agent is often underestimated when compared with other explosives—a deadly error in judgment. The most stable explosive materials, blasting agents require a stronger heat or shock source for detonation than high explosives such as dynamite; however, when it does explode, the blasting agent is just as powerful as dynamite. Firefighters must realize the danger and treat the blasting agent in the same manner as high explosives. The flames of a fire are certainly enough to detonate a blasting agent. A tragedy several years ago in Kansas City in which six firefighters were killed when a blasting agent exploded during a truck fire is a grim reminder of that hazard. Firefighting should never be attempted when the flames have reached any explosive. People and firefighters withdrawn rapidly to a distance of at least 2,000 feet from the burning explosive.

BLEVE: Boiling liquid expanding vapor explosion. A BLEVE occurs when a container of any liquid, but usually liquefied petroleum gas, ruptures. The BLEVE may result in a fireball, created by the ignition of the suddenly released vaporizing liquids, in rocketing pieces of steel shrapnel flying through the air, and in shock waves from the blast—all of which can kill firefighters.

Blind shaft: Interior light or air shafts that start at the first- or second-floor level.

Brick noggin: A construction term describing an ineffective brick partition wall in the roof space between wood studding, between buildings constructed in a row. It should not be depended on to stop horizontal fire spread. This wall of brick noggin was built as the wall separating the dwellings. The brick noggin wall from the cellar to the roof was designed to provide only soundproofing, not fire resistance.

Brush fires: Fast-moving fires that ignite grass, shrubs, bushes, scrub oak, chaparral, marsh grass (cattails), and grain fields.

Buttress: Masonry built against a church wall to give additional support.

Carbon monoxide: A colorless, odorless, explosive gas that is a toxic product of incomplete combustion. During a structural fire, there is usually insufficient oxygen for complete combustion to take place. The uncontrolled smoldering of a fire generates carbon monoxide. There may be gases in a fire area that are more toxic than carbon monoxide, but it is produced in large quantities that can be deadly. When mixed with air at low concentrations, 10,000 parts of carbon monoxide per million of air can cause death when inhaled for one minute.

Cellar: A story that has more than half of its level below ground and is not considered a floor level when computing the height of the building. The cellar is a below-grade floor level in a building. Firefighters die in cellars from carbon monoxide accumulation owing to incomplete combustion, from oxygen depletion owing to flash fires, from drowning in water-filled cellars, from breathing heavier-than-air gases that accumulate there, and from flammable gas explosions during fire. Some cellars are more dangerous than others. A cellar that is completely below grade, without windows, is more dangerous than a cellar that is only partially below grade or one that has windows to provide ventilation. Cellars in high-rise buildings do not have windows. Subcellars, the most dangerous type of below-grade area, have no windows and are two stories below the street level, directly below the cellar.

Chancel: A space reserved for clergy. The chancel includes the altar and the front choir area.

Class A fire: A fire that requires water for extinguishment.

Class B fire: A material fire of oils, cooking grease, and flammable liquids. This type of fire requires carbon dioxide or dry chemical extinguishers or fog streams for extinguishment.

Class C fire: A material fire of electrical equipment. To extinguish a class C fire, use the same carbon dioxide and dry chemical extinguishers as on flammable oils and grease. Shut off the electric power at the same time. Do not use water on an electrical equipment fire.

Class D fire: A fire that involves combustible metals and requires a dry powder extinguisher.

Cockloft: A common roof space. The cockloft is defined as the large concealed space between the top-floor ceiling and the underside of the roof deck. Fire may spread with explosive speed inside the cockloft.

Collapse: Any portion of a burning structure that collapses owing to fire damage. Firefighters outside burning buildings, as well as those inside, are killed by structural collapses. Unlike the other leading causes of firefighter deaths, when a building collapses during a fire, large numbers of firefighters die in a single event. New York City lost 343 firefighters when the World Trade Center collapsed on 9/11; Chicago lost 21 firefighters at a single structural wall collapse during a fire; Philadelphia lost 14 in a floor-and-wall collapse; Brockton, Massachusetts, lost 13 firefighters in a movie theater truss roof collapse; New York City lost 12 firefighters in a drug store floor collapse; in Boston, nine firefighters died in a floor-and-wall collapse when a hundred-year-old hotel under renovation suddenly fell; in Hackensack, New Jersey, 5 firefighters died when a truss roof collapsed during a fire in an automobile dealership fire; in Seattle, a floor collapse killed 5 firefighters; in Brackenridge, Pennsylvania, four firefighters died in a floor collapse; Lake Worth, Texas, lost 3 firefighters at a lightweight truss collapse in a church; and in Houston, 2 firefighters were killed in a lightweight roof collapse during a fast food restaurant fire.

Collapse danger zone: The most deadly area on the fire ground. When collapse is anticipated and a danger zone has been defined, no firefighter should enter it. A collapse danger zone is the ground area over which bricks from a collapsing wall will fall. It is the distance from the unstable wall equal to the height of the wall. When a brick or wood wall collapses in a 90°-angle collapse, it will kill any firefighter operating within the collapse danger zone; that is, a 20-foot-high wall collapsing at a 90° angle will kill firefighters operating within 20 feet of the wall.

Commercial building fire: A fire in a store, office or warehouse. A commercial building fire is more dangerous than a residential building fire. The number of firefighter deaths and injuries in residence fires is greater than those in commercial structure fires, but that is only because there are many more residence fires. Actually, the percentage of firefighters killed per incident is greater for commercial fires. Firefighters should take extra precautions when responding to commercial building fires. Additional dangers are present that are not found in residence buildings, such as dangerous industrial processes using chemicals and flammable liquids, dangerous machinery, unusual floor layouts, heavy floor loads, large floor areas, high ceilings, and greater fuel loads.

Communications at a fire: Notification procedures. Company officers and firefighters are responsible for notifying the incident commander of hazards discovered. Only an incident commander who receives a communication of a hazard can act to ensure safe operations.

Conduction: Spread of fire through a solid. The most common heat transfer by conduction takes place when heat from a burning stuffed chair or mattress close to a wall is transferred through a plasterboard wall into a concealed space or void.

Controlled burning in a high-rise building: Firefighters in the relative safety of the enclosed stairway waiting for the fire to burn itself out. This controlled burning can be considered by the incident commander only in a fire-resistive high-rise designed to confine a fire to one floor and only when the structure is not in danger of collapse. If the high-rise is not fire-resistive and fire spreads to the floor above or if the structure is deemed unstable, the occupants and firefighters must be withdrawn from the entire building, and an outside firefighting strategy will be ordered.

Convection: Transfer of heat by a fluid (gas or liquid). Fire gases spread heat at a fire—that is convection. The transfer of heat by convection can be seen when flames blow out a top-floor window beneath a roof overhang and spread into an attic. Fire spreading out a window, up to the underside of the roof eaves, is fire spread that must be stopped by an outside line; otherwise, there will be fire extension to the attic.

Corner safe zones: Four flanking zones around a burning building. When you look at a four-sided building from a bird's-eye view and if you imagine the four walls collapsing and covering the ground with bricks, you will find that there are four areas at the corners of the collapsed building that have fewer bricks.

Cornice: The decorative framework at the top or middle of a front wall. A decorative cornice of a row of houses that has a concealed space can spread fire horizontally.

Crown fires: Fires that are usually caused by the vertical spread of flames of a brush fire. Firefighters using hand tools and a small brush truck cannot extinguish a crown fire or even a large, fast-spreading brush fire.

Danger zone: A perimeter established around a propane truck or a large tank. The explosion danger zone at large propane tank or truck fires should be over 800 feet from the fire.

Dead-end hallway: A corridor extension beyond the exit door. A dead-end hallway is a pocket in which a person may be trapped during an escape from a smoky fire.

Defensive firefighting strategy: Protecting exposures, flanking a fire, positioning apparatus in corner safe areas, and so forth. Ninety-five percent of the fires in America are extinguished by firefighters using an aggressive interior attack. Five percent of structure fires require a defensive strategy. Defensive firefighting should be implemented against fires in buildings with lightweight truss construction; buildings with floors or roofs of unprotected lightweight steel bar joist; steel prefabricated buildings; and special-occupancy buildings, such as vacant buildings, buildings under construction, and buildings under demolitions. Fire departments are well trained in offensive attack strategies; however because defensive operating procedures are used less frequently, many chiefs, company officers, and firefighters are unfamiliar with and less effective in their use. Firefighter training should concentrate on defensive firefighters procedures.

Defensive overhauling: A strategy of using a master stream or several hose lines directed from outside the burning building and outside the collapse zone into the burning structure for several hours or days if necessary. Firefighters may be rotated each tour. Defensive overhauling, sometimes called a watch line, is continued for however long it takes until the smoldering fire is quenched.

Dirty bomb: An explosion that leaves residue that is contaminated by nuclear, biological, or chemical materials. In addition to the incident commander's ordering firefighters to use the protection of time, distance, and shielding, verification of the surrounding area for contamination or reports of a dirty bomb should be obtained from officials on the scene and the dispatcher. Chemical experts should be called to the scene to analyze the atmosphere. If contamination of the area is confirmed, a hazardous material incident should be declared.

Disorientation: The loss of direction firefighters experience when searching a smoke-filled room. It happens primarily when firefighters fail to use an organized search technique when moving around the smoky room and prevents firefighters from returning to the safety of the door or window of entry. Disoriented firefighters often are killed by flashover or die from asphyxiation in smoke after their masks run out of air. It doesn't take a large space for disorientation to occur: The bodies of firefighters have been found next to doors and windows in 10-foot-by-10-foot rooms that had been filled with thick smoke.

Dome: A hemispherical church or temple roof on a circular tower or base.

Electric shock: When electricity passing through the body brings about violent muscular contractions of the heart, interrupts the breathing process, or burns vital internal organs in the path of the electric current. Most firefighters who are killed or injured by electricity come in contact with overhead utility wires when climbing ladders or operating on aerial platforms. Consider all electrical wires and equipment live and dangerous.

Elevators: Death traps during a fire in a high-rise.

Emergency withdrawal: A more urgent withdrawal than a normal order to back out of a burning building (as usually happens when changing strategy from interior to exterior operations). When an order is given for emergency evacuation, the danger is imminent, and speed of withdrawal is imperative. All heavy tools and hose are left behind during an emergency evacuation. For an emergency withdrawal to be carried out, there must be a prearranged emergency signal known by all member of the department. An emergency withdrawal signal may be long-term use of all apparatus air horns or a portable radio frequency tone.

Evacuation stairway: The stairway used for occupant evacuation.

Explosion: A violent combustion reaction of fuel, oxygen, and heat that creates rapid expansion of gases strong enough to collapse an enclosing structure or create shock waves that break glass windows or knock down nearby firefighters. There are many types of explosions; BLEVEs, backdrafts, IEDs, blasting agents, high explosives, low explosives, flammable gas, and natural gas are also causes of explosions.

Explosive classifications:

- **Class A explosives**: Maximum-hazard explosives, including dynamite, nitroglycerin, mercury of fulminate, black powder, and blasting caps.
- **Class B explosives**: A high-flammable hazard, including most propellant materials.
- **Class C explosives**: Fireworks, explosive rivets, and detonating cord.
- **Low explosives**: Fire constituents including black powder, smokeless powder, and rocket fuels.
- **Primary high explosives**: Mild shock or heat detonators—for example, mercury of fulminate.
- **Secondary high explosives**: More powerful than primary high explosives, detonated by shock from a primary explosive—for example, dynamite and nitroglycerin.

Exterior defensive attack strategy: A procedure for conducting exterior defensive attack. A general rule passed down from veteran chief to new chief states that if fire is on two or more floors and the hose lines are not making headway, an outside attack strategy should be considered.

Exterior defensive hose line attack: A strategy used when other strategies are considered ineffective or too dangerous and all occupants have been evacuated from the building. All interior forces are withdrawn to safety. This can be a temporary strategy, with firefighters returning inside the building with hose lines, or a final strategy, such as a surround-and-drown operation.

Falling objects: A leading cause of deaths on the fire ground. They are any materials that fall from, are thrown out of, or break off a fire structure or exposed structure during a fire—for example, smoldering pieces of furniture thrown out of windows during overhauling, window air-conditioners, falling tools that have slipped out of the hands of firefighters overhauling window frames, broken glass from windows vented from inside a burning building, and even people jumping out of buildings to escape flames. The most likely place to be struck by a falling object is the perimeter of a burning building. To avoid injury by falling objects, get inside the building or stay away from the perimeter.

Fingers of a brush fire: Strips of long, thin sections of fire that extend outward from the main area of blackened earth.

Firefighting strategy: The steps of firefighting strategy at a row house or strip mall: (1) Protect life with the first hose and sometimes a backup attack line. (2) Prevent fire extension (downwind) with the second hose line. (3) Confine the fire (upwind) with the third line. (4) If the rear of the building is spreading fire, stretch a line to this location. (5) Extinguish the fire with all lines confining the fire. At most fires, the first hose attack team stretches one hose line, extinguishing the fire and performing all five firefighting strategies simultaneously.

Fire resistive: Material that will resist fire for a designated period of time, such as one, two, three, or four hours. Steel columns, girders, and beam in a fire-resistive (type I construction) building will be covered with fire retardant.

Flame: The luminous zone of combustion when one gas burns in another. Flame temperatures are between 2,500 and 3,500°F. Along with gases, heat, and smoke, burns are a leading cause of death on the fire ground. The best protection a firefighter has against flames is water from an attack hose stream. The insulation of protective firefighting gear and mask will protect a firefighter from more serious injury when exposed to the flames of flashover, flash fire, or reflash fire, but nothing can protect a firefighter from prolonged exposure to flames. Flame is the most deadly and most common hazardous material a firefighter will ever encounter.

Flameover: A fire described by the National Institute of Standards and Technology as a fire that rapidly spreads along the surface of a wall, ceiling, or floor. The flameover fire was first reported at the Winecoff Hotel fire, in Atlanta, Georgia, in 1946, where 119 people died in the upper-floor rooms.

Flammable-vapor explosion: Caused by the instant ignition of flammable vapors and gases mixed in air. Flammable-vapor explosions often occur during arson fires in which flammable liquids are used to speed the spread of fire. Unexplainable explosions during fires are often flammable-vapor explosions. When an explosion or flash fire occurs in an adjoining room or occupancy next to the area of fire origin or a flammable-vapor explosion is caused by a flammable liquid, arson should be suspected. This happens often in such adjoining areas to a fire. Flammable vapors can drift into the adjoining occupancy and explode even after the main fire has been extinguished; all it requires is a spark from the main fire.

Flanking a fire: A firefighting strategy used in the following instances: When a wall appears unstable and in danger of collapse, set up master streams in a flanking position in front of the walls of adjoining buildings. If there is a danger of an explosion, position hose lines in a flanking position away from the doorway. When operating at a fast-moving windblown wildfire, position firefighters in a flanking position on each side of the advancing fire. At a fire in a high-rise office building, with a center core design, when the first attack hose line is unable to advance on the fire because wind blowing through a broken window pushes fire into the path of the advancing firefighters. A second line is the flanking attack hose line.

Flanking hose attack: A hose line advance toward a fire by the second or third hose team. This hose team uses an alternative approach, from a right angle, to advance on a fire while firefighters of the first attack hose team take cover.

Flanks of a brush fire: Looking at the fire from the rear of the blackened area, the left side is the left flank, and the right side is the right flank.

Flare-up: The sudden explosive flaming of a brush fire caused by a strong wind gust or change in wind direction. Firefighters working in high, dense brush have been trapped and killed by flare-ups when fighting wildfires. A flare-up is also the sudden, rapid ignition and then immediate self-extinguishment of a room filled with a flammable atmosphere. It is caused by a pocket of flammable gas, vapor, or dust that suddenly comes in contact with an ignition source. However, because the flammable vapor, gas, or finely divided dust is insufficient in quantity, the fire self-extinguishes usually when a material just reaches its flash point.

Flashover: The rapid ignition of heated fire gases and smoke that have built up in a burning room. Flashover is caused by thermal radiation feedback (sometimes called re-radiation) from the ceilings and upper walls, which have been heated by the fire growing in the room. When all the combustibles in the space have been heated to their ignition temperatures, simultaneous ignition of the room occurs. Flashover is full-room involvement with fire. It occurs during the growth stage of a fire. Civilians and firefighters in the room will not survive. After flashover occurs, all searching stops because the fire is too severe; an attack hose line is now required for extinguishment, and there is a possibility of collapse.

Flowing the floor: Direction of water from a hose stream into doorways or windows, to spread across the first floor above an out-of-control cellar fire. This strategy is used when the first floor becomes too dangerous for firefighters owing to smoke or collapse.

Flying brands: Windblown pieces of burning wood embers. Flying brands are another exterior fire spread problem created at heavy timber mill fires. During a nighttime fire in a heavy timber building, flying brands will light up the sky. During the daytime, they may be overlooked in the smoke issuing from the burning building. These airborne burning embers must be considered a serious fire spread problem. When a windblown (convection currents) hot wooden ember lands on a roof and ignites wood shingles, the spread of fire to the roof can be considered heat transfer by conduction.

Frontal attack strategy: Firefighters advancing an attack hose line inside a burning building toward a fire. Firefighters advance a hose line directly into the path of the raging fire. Firefighters using a frontal attack confront the fire heat and smoke head-on. The firefighting strategy used by most fire departments throughout the country is an interior attack using a small-diameter hose stream. This strategy extinguishes all content and some structure fires in a building.

Frontal hose attack: A frontal hose line attack strategy by the first hose team of firefighters. This is the most common hose placement strategy used by the fire service. The frontal attack is successful at 95% of fires.

Gothic church: Architecture of the 12th century, featuring a pointed arch.

Ground fires: Slow-spreading, smoldering fires that burn in dried, decomposed leaves, twigs, or pine needles that have fallen from the trees to the ground. These are also called bog fires.

Ground floor: A common and confusing misnomer. The lowest floor is called the first floor, not the ground floor. Some buildings are mislabeled as having a ground floor, then a first floor, a second floor, and so forth. There is no such fire department term as ground floor; it is the first floor.

Group think: A mode of thinking found in cohesive highly disciplined teams. Group think occurs when the group strives for unanimity in action and when all members of the group concur with the objectives. Most highly disciplined organizations, like a fire service and the U.S. military, exercise this type of thinking during emergency operations. This mind-set has both good and bad effects. At most (99%) emergency operations, group think in the fire service is good. It helps us accomplish objectives during dangerous emergency conditions efficiently. To be successful, all members of the fire service must understand and work for the same objectives. However, in rare (1%) instances, group think can be deadly. Group think can have negative results when firefighters, striving for unanimity of action, let it override a realistic awareness of the situation. In this instance, group think may stop us from considering an alternative course of action.

Hazardous material: Any chemical, biological, or nuclear substance that can cause death or disabling injury during or after exposure. The most common hazardous materials that a firefighter will encounter are the byproducts of ordinary structural fires. Combustion byproducts kill more firefighters than any other known hazardous materials.

Hazardous material work zones: The three hazard work zones: (1) The hot zone, or exclusion zone; (2) the warm zone, or contamination reduction zone, and (3) the cold zone, or hazard-free zone or noncontaminated zone.

Header beam: A header beam is the beam at the top of the opening.

Head of a brush fire: The leading edge of a moving brush fire.

Head of a wildfire: The fast-moving leading edge along which a grass fire, brush fire, or treetop fire (crown fire) is advancing. It is the most dangerous area of the fire ground. Firefighters have been trapped and killed by the rapid spread of flame at the head of a wildfire.

Heat: One of the products of combustion. Heat is associated with the natural motion of molecules: the faster the molecules in a material move, the hotter the material becomes. Firefighters' protective clothing and breathing equipment cannot protect them from the heat of a fire. Dry-air temperatures above 280–320°F will cause extreme pain to unprotected skin. Exposure to a temperature of 160°F for 60 seconds will cause a second-degree burn; 180°F for 30 seconds and 212°F for 15 seconds will do the same.

Heavy timber construction: A structure that has masonry walls and interior structural framing wood columns with dimensions of at least eight inches by eight inches, girders at least six inches thick, and four-inch-thick floors (tongue-and-groove planks, not less than three inches in thickness and covered with one-inch flooring laid sideways). I have never seen a factory or mill building with a floor that satisfies the last requirement.

Hell's Hundred Acres: Name given to an area in New York City that has heavy timber constructed buildings. Many firefighters were killed by burning building collapses there in the first half of the 20th century. The collapse danger of these heavy timber buildings is a multilevel failure of the structural framing, floor, and wall collapse. During an uncontrolled fire, first the cast-iron structural framing (columns and girders) will fail, triggering the floors to cave in; then, the falling floors cause the walls to collapse.

High ceilings: Ceilings of more than 10 feet above floor level. High ceilings are a danger to firefighters. A high ceiling in a commercial building provides space for dangerous heat and flame buildup above the heads of firefighters searching in smoke. In a smoke-filled room in a residential building with a ceiling between 8 and 10 feet above floor level, a firefighter sizes up the flashover danger by how low he or she must crouch to crawl under the heat banking down from the ceiling. In a commercial building with 15- to 20-foot ceilings, however, this conventional forecaster of flashover danger is insufficient; the flashover danger may exist well before the heat reaches the firefighters. Failure to recognize this could be a fatal error in judgment. To size up flashover danger, look for sporadic flaming in the smoke, or communicate with members above the fire floor to find out if they feel heat where they are operating.

High-hazard occupancies: Warehouses and bulk-storage buildings.

HVAC: Heating, ventilation, and air-conditioning. HVAC systems are ductwork systems connecting several floors or public halls and corridors of high-rise buildings

Hydraulic overhauling: The long-term use of master streams to quench smoldering or spot fires after a fire has been declared under control. This strategy is also referred to as surround and drown or defensive overhauling. Water from deck pipes, aerial stream, and portable deluge nozzle can be used to fully put out a fire and prevent a rekindle, instead of sending firefighters inside to turn over and pull apart smoldering rubble.

Hyperthermia: A cause of death that may occur if your body absorbs heat faster than it can be dissipated by evaporation of surface moisture.

IED: Improvised explosive devise. An IED is not a bomb. It is any type of explosive material that can be stuffed into a bag, pipe, bottle, can, package, or 55-gallon drum.

IED explosion danger zone: The recommended strategy, when there is a danger that a bomb or an IED may be detonated. The strategy is to stop firefighting and withdraw bystanders rapidly to a minimum of 2,000 feet from the site.

Incident command system: A strategy for command. The incident command system is now called the National Incident Management System (NIMS) by the fire service. The five management or command functions are command, operations, planning, logistics, and finance.

Interior defensive attack strategy: The strategy when an interior defensive hose line is operated by firefighters in a stairway enclosure for a long duration. This is also called a controlled-burn firefighting strategy. The hose line keeps the fire from entering the stair enclosure. Smoke may enter the stairway, but fire will not be allowed to spread up the stairway. This strategy gives firefighters time to make aerial ladder rescues and searches of upper floors from other stairways. An interior defensive operation can only be carried out when the stability of the building is ensured. When the building stability is in question, an outside defensive attack or a nonattack strategy is more effective.

Interior defensive hose line attack: The strategy used when firefighters must maintain control of a stairway and operate a hose stream from a stairway into an occupancy doorway. The hose team does not advance toward the seat of the fire owing to its size. This strategy is often used when fire is above the reach of the highest ladder and cannot be extinguished by an outside master stream and when there is a life hazard in the building above the fire that must be evacuated. This strategy is used when fire is confined to one floor of fire and where the stability of the structure is sound. The intent of this strategy is to eventually advance on the fire when the furnishings providing the fuel to the fire on the burning floor are consumed.

Large-area occupancy: An enclosure greater than 25 feet by 50 feet without any interior enclosing partitions. Search and rescue in large-area occupancy (e.g., warehouse, theater, church, or store) can be extremely dangerous.

If the occupancy becomes filled with dense smoke, there is a good chance that firefighters will become disoriented and lost under such conditions. They will be unable to find their way safely back to the entrance, in which case they run the risk of asphyxiating after their air supply runs out or being caught in rapidly extending fire. Firefighters should use a search rope when searching in a large-area occupancy. Tie one end of the rope to the entrance door or to a fixed object near the door and play out the other end as you search the interior of the occupancy. The search rope will guide you back to safety when smoke reduces visibility.

Low-hazard occupancies: Offices, banks, and schools. If the quantity of combustible material inside the office, bank, or school becomes excessive or flammable liquid is introduced, the occupancy is no longer low hazard, and the noncombustible (type II construction) structure must undergo an upgrade in fire protection.

Mail bomb: Usually a small package sent through the mail. A letter (package) bomb often kills or injures the wrong person.

Master stream: A ground-based or aerial device with a fog or straight stream, capable of delivering more than 300 gallons per minute to a fire. Handheld nozzles attached directly to a hose line delivering this amount of water volume and pressure are too difficult to control and direct, so mechanical, electrical, or hydraulic assists are required. Fog streams with a delivery rate of more than 300 gallons per minute and solid-stream nozzles of 1½ inches or more in diameter are considered master stream nozzles.

Moderate-hazard occupancies: Retail shops, factories, and workshops.

Molotov cocktail: A World War II antitank weapon named after a Russian government official. It is the weapons of choice of urban terrorists acting out at civil disturbances. This type of IED can be identified by a bottle filled with liquid and piece of cloth at the opening; the liquid is a mixture of gasoline and sulfuric acid, and the bottle is capped and wrapped in a sock soaked with potassium chlorate and sugar.

Mushrooming: The horizontal flow at ceiling level and subsequent banking down to floor level of smoke and heat generated by a fire in a confined space. The rapid mushrooming of smoke and heat traps and disorients firefighters during search-and-rescue operations. It occurs more rapidly in small rooms. Venting roof skylights, stairways, and windows can delay or eliminate mushrooming of smoke and heat in confined spaces during a fire.

Nave: A main seating area of a church.

NFPA 704 diamond: A vital piece of preplanning information. Failure to note or understand its meaning could be a fatal mistake for the firefighter. The number 4 printed in any one of the spaces of a hazardous material diamond—health hazard, flammability hazard, explosive hazard, or special-information space—tells us that the hazard in the room or container is too dangerous to approach. Withdraw immediately from the area and obtain expert advice about the hazard. There should be no firefighting.

Nonattack strategy: Used when there is a serious fire in a structure and people are descending a stairway. Instead of opening the door to attack the fire with a hose line, when the stairway is crowded with people descending past the fire, the door is kept closed, and the hose team does not attack the fire. In this instance, the fire officer keeps the door shut until all people pass below the fire. Then, the door is opened and the fire is attacked. A nonattack firefighting strategy is also used when a serious fire is beyond control of firefighters' hose streams and people are being evacuated from the floors above in a high-rise structure. The nonattack strategy was used at the World Trade Center terrorist attack and fire on 9/11. The incident commanders, realizing the fires were too great for manual firefighting, sent firefighters into the high-rise towers equipped with masks and tools to perform search and rescue of trapped victims. The nonattack strategy can be implemented for a short duration in a narrow tenement hallway, until several people are removed down below the fire, or it can be implemented for a long duration at a high-rise office fire beyond control of an attack hose team.

Noncombustible: Materials that when not covered with fire retardant cannot resist fire. Noncombustible does not mean the same as fire resistive. If noncombustible steel columns, girders, and open bar joist are not covered with fire-retarding material, they will not resist fire and will collapse quickly when heated by a fire. Steel is not fire resistive; it is noncombustible. When heated by fire, it fails and can collapse a building. The steel does not burn when heated, but it expands, warps, twists, bends, buckles, and loses its tensile and compressive strength and does not support the building loads it was designed for.

Overhauling: The firefighting operation undertaken after a fire is under control. Overhauling is intended to prevent the rekindle of a fire after the department leaves the scene. Its dangers often are underestimated; many firefighters have been killed and injured during this stage. Building collapses, falls into open shafts, carbon monoxide accumulation in below-grade areas, electrocution, and stress from the physical exertion of pulling down ceilings to examine for hidden fire and gas explosions are some common hazards during overhaul.

Parapet wall: A freestanding wall that continues beyond an exterior wall above the roof level. A parapet wall is waist high and encircles the roof. Decorative-front parapet walls suddenly collapse during fires. There are three classifications of brick walls: freestanding, nonbearing, and bearing. The freestanding parapet wall is the least stable. A brick parapet wall extending over large display windows of a one-story commercial building is supported by a steel I beam. If the windows are vented during a fire and flames flow out, the heat can distort the steel I beam, causing the brick parapet wall above it to collapse.

Partial defend in place: An evacuation strategy. During a fire in a high-rise office building, the fire service must fight the fire while most of the people remain inside the burning building. This strategy requires the incident commander to evacuate the people closest to the fire—those on the fire floor and the floor above. They are removed to safety below the fire. The commander then orders all other people to remain in the building unless smoke is entering their floor. If people instructed to remain in the building notify the chief that smoke is entering their floor by way of the HVAC system ducts, that floor will also be evacuated, and firefighters will be sent to assist. For a partial-defend-in-place firefighting strategy to be implemented, the building must be structurally sound—not about to collapse. Most important, the building must be fire resistive. You cannot order people to stay in place during a fire if the building will not resist fire spread. The definition of a fire-resistive building is a structure that will contain fire to one floor and is subdivided with partition walls to confine fire and smoke spread to small manageable proportions. Fire must be confined to areas small enough for firefighters to extinguish with handheld hose streams. Floors and walls inside a fire-resistive building must contain fire and create areas of refuge in the building where occupants can remain during a fire. Since the collapse of the World Trade Center towers and the revelation of the weaknesses of high-rise fire-resistive construction—such as the spread of smoke through the central air ducts—the partial-defend-in-place strategy for commercial buildings has been called into question.

Passive fire protection: The fire containment provided by the building construction of a structure. Passive fire resistance does not exist today.

Performance building code: A code that allows the use of any material that performs well in a laboratory test fire. The performance code has allowed builders to use lightweight construction materials that fail rapidly during fire.

Place of assembly: Most building codes consider places of assembly as those having an occupancy of over 50 people. The New York City building code declares a place of assembly as a restaurant containing more than 75 occupants.

Plastic: A material that contains one or more polymeric organic substances of high molecular weight. Thousands of plastic products are used in furnishings, fabrics, and building construction materials. While the flammability of a plastic product depends on its form, plastics generally create hotter fires and are therefore more dangerous to firefighters than burning wood, paper, or cloth. One pound of polystyrene plastic can give off 18,000 BTUs, whereas wood or paper will only give off 7,000–8,000 BTUs. Furthermore, the smoke given off by plastics is dense and black, creating a greater obscuration hazard than wood or paper smoke. The rate of burning during a plastics fire is quite rapid, which can speed up the time it takes for a room to flash over. It all adds up to the firefighter's work environment: the burning room has become more dangerous over the past 30 years because of the increased use of plastics in the home.

Pockets of a brush fire: Sections of unburned shrubs or trees inside the large blackened area of a brush fire.

Preliminary radio report: The first progress report. The preliminary report requires the incident commander to give a radio report of the fire description, the fire building, the surrounding property, and the fire spread. For example, "We have a fire in a 2½-story, wood frame building 25 ft. × 50 ft; fire is located on the second floor and possibly the attic."

Preplan: A three-page document based on prefire inspection: (1) fact sheet; (2) diagram; and (3) strategy and tactics recommendations. The fire preplan is programmed into the computerized dispatch system.

Pressure-reducing valves (PRVs): Valves that should be removed from the standpipe outlet valve supplying the attack team hose lines. The valve opening should have been flushed out to remove debris before connecting the hose. If available, a pressure gauge should be attached between the outlet and the hose line.

Primary search: The first search of a fire area. It is performed in a quick, systematic fashion during the fire extinguishment stage. When conducting a primary search, firefighters should examine the areas that provide the greatest chance of finding a victim. Most fire survivors are discovered during the primary search.

Priorities of firefighting strategy: The priorities on which all firefighting decisions should be based: Protect life first, including the lives of firefighters. Incident stabilization is the second priority of firefighting. Property protection is the third and last priority of firefighting.

Public hallway: A corridor that connects the stairs to the apartments. The public hallway becomes involved in fire when a burning apartment door is left open by the occupant fleeing a fire.

Quenching, venting, and flanking: Three strategies firefighters can use for protection against backdraft smoke explosions. Directing a hose stream into a door or window to a room containing a possible explosive atmosphere is quenching. The water stream directed into the explosive smoke and heat atmosphere may interrupt (i.e., quench) a developing explosion. When a door or window appears to have an explosive atmosphere developing, by directing a hose stream into the superheated smoke, you may break up the explosive atmosphere and prevent an explosion. Venting roof skylights and scuttle covers can act as a relief valve for an explosive atmosphere. If these roof openings are vented and an explosion occurs, part of the blast will be diverted upward, out these roof opening. Flanking is a safe operating procedure that firefighters can use when there is a danger of an explosion blowing out of a doorway or a window opening. When flanking a door, firefighters position themselves on each side of the doorway, away from any potential blast or shock waves that may come through the doorway. A hose stream operating in a flanking position at a door should be operated at angles that allow the water stream to enter the doorway and keep firefighters out of the path of any blast that may come through the doorway or window of the burning store.

Radiation heat transfer: The transfer of heat through space. The transfer of heat by radiation is unusual; it does not occur as frequently as convection or conduction. Because it does not happen as often, and because it happens suddenly, and because it is invisible, we are not as effective preventing it from happening.

Rapid intervention team (RIT): A team or a ladder company standing by during a fire to rescue a trapped, missing, or injured firefighter. An RIT helps a chief react to one of the worst emergencies that can happen on the fire ground—a missing or trapped firefighter.

Rear of a brush fire: The opposite side of the head of a brush fire.

Reflash fire: The sudden ignition of flammable gases or smoke inside a smoldering kitchen fire that has just been extinguished by a portable extinguisher or a hose stream. After a fire has been knocked down and the hose stream has been shut down, there still may be sufficient heated gases and smoldering embers in a room to suddenly reflash if oxygen enters the area. Reflash fires often trap firefighters making a quick primary search after the fire has been extinguished.

Rekindle: A blaze that reignites after a fire company leaves the scene of a fire. A rekindle describes a situation in which, after a salvage and overhauling have been completed and a blaze is officially declared extinguished, firefighters go back to the firehouse and are later called back to the burning building to fight the reignited fire. Sometimes the second fire is much worse than the original fire, and worse yet, sometimes the second fire kills people who assumed the fire was extinguished. A rekindle is an indication of a poor firefighting operation.

Residential building: The occupancy in which the most fires occur and the most firefighters are killed and injured. This refers in particular to one- and two-family houses. Wildfires and store and office fires are second and third, respectively, on the list of incidents in which firefighter deaths occur.

Responding to and returning from alarms: The cause of 25% of the firefighter deaths each year in the United States. Apparatus rollovers, intersection accidents, and rear-end collisions are very real dangers of firefighting. Two factors present during death or injury at an accident are speed and failure to use seat belts.

Rollover: The sporadic ignition of combustible gases at ceiling level during the growth stage of a fire. Rollover precedes and is an indicator of possible flashover (in addition to high heat and smoke banking down to half the height). Firefighters without the protection of a hose line should consider withdrawing from a smoke-filled room when rollover starts to occur. Rollover will be visible near ceiling level or, mixed with heat and smoke, will flow out of the top portion of an open doorway or window.

Rose window: A large round window at front of a Gothic church.

Satchel bomb: Explosive material placed into a backpack or satchel. This is an IED. Several sticks of dynamite placed in a shoulder-strap bag with one or two small liquid propane cylinders can create a tremendous explosion and fire.

Secondary search: A methodical search for victims, following primary search. A quick primary search is made first to look for unconscious victims while the attack hose line is advanced. The secondary search is a more methodical, slow, and careful search of the entire fire building and area around the burned-out building for victims. This search will include the same area as the primary search plus adjoining bedrooms, the floors above and below the fire if necessary, and the area outside around the perimeter of the building, where people trapped by flames could have jumped out windows. The secondary search is usually executed after the fire is controlled, and results are reported to the officer in command after searches are completed. If there is a danger of collapse that threatens searching firefighters, the search may be cancelled. This decision should be transmitted over the department radio with the last progress report and recorded in quarters.

Seventh side of a fire: The combustible outside walls and siding of a wood dwelling (type V construction). Flames often spread along the outside surface of the burning dwelling.

Shafts: Vertical spaces in some multistory row houses, intended to bring sunlight and air into rooms of the apartments. These shafts have windows built into the walls, allowing rapid vertical fire spread from floor to floor. Also, when fire enters the shaft, it may spread vertically, sometimes into the common roof space at the top of the shaft through the eaves (the wood framework around the top opening of the shaft.) Fire must not be allowed to enter the shaft; if fire already is in the shaft, it must be extinguished quickly. These 2-ft. × 2-ft. interior light shafts may be enclosed by four plasterboard or wood walls. Located in the interior of the building, they extend from the basement to the roof. In some cases, the shafts start at the first- or second-floor level and are called blind shafts.

Size-up: Evaluation of an incident from inside and from outside a burning building. For example, the operations officer is in charge of the initial hose line and, as the interior search operation officer, he or she makes an inside size-up. The incident commander, outside the burning building, at the command post, is in charge of the entire operation and will conduct an outside size-up.

Smoke: Finely divided particles of soot and aerosols that accompany an uncontrolled fire. Smoke from incomplete combustion kills and injures firefighters in the following ways: it causes asphyxiation, explosions, reduced visibility, and disorientation and entrapment. To reduce the dangers of smoke during a fire, ventilate the smoke-filled area in a coordinated, controlled manner.

Smoke explosions (backdrafts): Explosions caused by the random accumulation of combustible, smoke-filled atmospheres in confined spaces during a structure fire. They often occur in the main fire area during both the growth stage and the decay stage of a fire. A smoke explosion that occurs in the main fire area during the decay stage often is called a backdraft explosion. A smoke explosion can also occur in a room adjoining a fire in the fully developed stage. For example, it can occur in a smoke-filled room on either side of or above the room that is actually burning. Smoke seeping from the main fire into adjoining spaces creates a combustible atmosphere. When searching firefighters open up adjoining combustible rooms, a smoke explosion occurs. The ignition source is the heat of the main fire area; the fuel is the combustible smoke that spreads to the adjoining spaces and creates a combustible atmosphere; the oxygen comes with the initial entry of the firefighter searching for fire victims and fire spread.

Spandrel wall: The exterior wall between the top of one window and the bottom of the window above.

Specification building code: A code specifying the type and size of material to be used in construction of walls, floors, and other building components.

Spot fires in a brush fire: Isolated pockets of fire some distance downwind from the main fire and fingers.

Stages of fire: The three stages of fire growth: (1) In the growth stage, the fire grows from a small area to engulf an entire room. (2) In the fully developed or active flaming stage, fire engulfs the entire room. (3) In the decay stage, the flaming begins to subside, and the temperature in the room decreases.

Staging, level I: Staging procedure at the early stages of a routine fire: Only the first-arriving engine and ladder should enter the street where the fire or emergency takes place. This should automatically be performed by first arriving units.

Staging, level II: Staging procedures when it appears likely that a major incident will occur: A chief responding to a major fire or emergency should designate a location as the staging area and a staging officer. If there is a known empty space or parking lot nearby, this area can be designated as the staging area by the chief. This is critical during a large incident.

Standard operating procedure: A strategy for having arriving fire companies perform a specific task and at a specific location. Standard operating procedures provide accountability and control.

Steeple: The tapered pointed structure on top of church tower.

Strategy: Planning and directing large numbers of firefighters, apparatus, and equipment during a fire. The word strategy is synonymous with plan; thus, a firefighting strategy is a plan of action—in other words, how to extinguish a fire. A fire chief's strategy is an organized way of proceeding during firefighting. An example of an extensive firefighting strategy (plan) is as follows: protect life safety first, prevent fire extension, confine fire, perform fire extinguishment, salvage and overhaul, prevent rekindle, and secure the area. Firefighting strategies are flexible: they change and have alternatives. By contrast, firefighting tactics are fixed—constant and unyielding.

Stress: The physical and psychological exertion and pressures caused by the demands and dangers of firefighting. Stress from firefighting can cause cardiac arrest, stroke, or aneurysm. Firefighters between 51 and 66 years of age are those most often killed by the physical and psychological stress of firefighting.

Subcellar: A floor level below a cellar level, sometimes found in a commercial building. Unless cellar and subcellar fires are detected in the early stages, it is rare that an offensive hose line attack strategy will be successful.

System analysis: A method of analyzing the problems indigenous to structural firefighting. Any one of the parts of the system (i.e., problems) can disrupt the firefighting operation. The 13-point size-up used by some in the fire service is a system analysis. A system analysis of a structure fire includes the following: size and location of the fire, construction type of the fire building, the occupancy of the burning building, the area of the building, the height of the burning building, the life hazard, the adjacent exposed buildings, the apparatus on scene, the personnel who responded with the apparatus, the water supply, the auxiliary appliances available for use, the time of the fire occurrence, and the weather conditions. An incident commander will not consider all of the systems, just the ones that present a problem at a fire or emergency and require action to resolve.

Tactics: Operations of fire companies at a fire or emergency. For example, hose stretching and ladder raising are firefighting tactics. Firefighting tactics lead to accomplishing the firefighting strategy. Tactics are fixed (constant and unyielding), whereas strategies are flexible.

Target hazard: A building or occupancy that is considered hazardous and requires special attention, such as increased inspections, prefire planning, defensive firefighting procedures, fireguards, or an order to vacate the premises.

Taxpayer: Another term for a strip mall store. The cheaply built taxpayer of yesteryear was ordinary (type III) construction; an associated construction defect is a common roof space that allows fire to spread rapidly over all the stores once flames extend to the roof space. Today, the new taxpayer also is a low-cost building; it is a noncombustible (type II construction) structure: the so-called steel building. There may or may not be a fire spread problem caused by a combustible common roof space; however, with type II construction, there is a roof and floor steel bar joist system that may fail within 5–10 minutes of fire exposure.

Total defend in place: An evacuation strategy. The strategy for evacuating people from a high-rise residential building is different than the strategy of evacuating people from a high-rise office building. During a fire in a high-rise residential building, we must fight the fire while all people in the building remain in their apartments. No one is assisted to leave by firefighters. Unlike a fire in an office building, in a fire in a residential high-rise, everyone stays in place. The evacuation strategy in a residential high-rise is a nonevacuation strategy called a total defend in place, wherein everyone stays in the apartments, except for the people in the fire apartment. If a high-rise is higher than the reach of the tallest fire department ladder, the building must be fire-resistive construction.

Tower of a church: The square structure rising above the church roof. Sometimes there is a steeple constructed atop the tower.

Transept: A space that runs at a right angle to the nave and the chancel in a church.

Transit: A surveyor's tool. By looking through the telescope, firefighters can monitor a collapse danger from a distance. A transit can detect a building's shift or the widening of a crack that is not visible to the human eye.

Trench cut: Used when fire is already spreading in a common roof space. A trench cut is not a substitute for cutting a vent opening directly over a fire in a roof space. Roof vent cutting over a fire is to prevent horizontal fire spread by releasing heat and fire vertically. A roof vent cut should always be done before a trench cut. If a roof vent cut is successful, a trench cut will not be necessary. Cutting a trench takes time and a large number of personnel, so if necessary, a roof trench opening should be cut several stores away from the fire. Before the trench is cut, a hose line should be positioned below and on the roof, to stop the fire spread. At most trench cut operations, the hose lines stop the fire, not the trench cut.

Triangle Shirtwaist fire: A fire in New York City in 1911. Fire drills in heavy timber factory buildings in New York City were first required by the New York State labor law enacted after 146 women died in the Triangle Shirtwaist Company fire in 1911. The law is now the legal basis for requirement that fire safety organizations be established in high-rise office buildings.

Triforium: A middle story of a church (side balconies).

Trimmer beams: The beams on each side of the opening.

Truss: A structural composition of wood or steel, joined together in groups of triangles, arranged in a single plane, so that loads applied at points of intersecting members will cause only direct stress, such as tension or compression. The groups of triangles are fastened together by metal bolts, sheet metal surface fasteners, or welds. Truss construction is a dangerous roof or floor design when exposed by fire. The large surface-to-mass ratio of the truss and many small, interconnecting members make it vulnerable to early collapse. Truss roofs kill firefighters working below the truss, on top of the truss, and outside the truss roof building. When a timber truss roof collapses, it can cause the collapse of an outside bearing wall.

Unabomber: Domestic terrorist Ted Kaczynski. The Unabomber killed 3 and injured 17 over 23 years by sending package bombs to people associated with airlines, universities, and corporations.

Uncontrolled environment: A dangerous smoke-filled, collapse-prone, or explosive atmosphere area in which firefighters work. Combat soldiers and firefighters operate under the most dangerous, uncontrolled environments of any occupations. Coal miners must have lighting, fresh air, and structural supports in the mine before they go to work; firefighters, when they crawl into a smoke-filled room, have no such safety guarantees. They must bring their safety equipment with them, including flashlights, protective breathing equipment, and a powerful hose stream.

Urban firestorm: The rapid rise in fires occurring in the Northeast and Midwest in the 1970s. The urban firestorm was fueled by vacant buildings. As people fled the cities and crime in the 1970s, they left thousands of vacant buildings. When the Bronx was burning, it was in the thousands of empty buildings in the Bronx left behind by the people moving to the Sunbelt. The urban firestorm of the 1970s should have been called an arson/vacant building firestorm.

Venting: The planned, systematic removal of smoke, heat, and fire gases from a burning building. There must be purpose to venting a fire. If venting is not controlled, it can have adverse effects on the firefighting strategy.

Watch line: A similar strategy to hydraulic overhauling or defensive overhauling. A watch line is an overhauling strategy in which the chief leaves one engine or ladder company on the scene all night or for several days to wet down the smoldering building with an aerial stream or hose line.

Worcester Cold Storage Warehouse: The deadliest fire in a heavy timber building in modern times. The fire occurred in New England, where such construction originated. In December 1999, in Worcester, Massachusetts, six firefighters died after being trapped by fire inside a heavy timber structure, the Worcester Cold Storage Warehouse. Factors contributing to the firefighter fatalities were a fire set by homeless people in a partially vacant building, delayed alarm notification to the Worcester Fire Department, rapid fire spread up an open elevator shaft, dense black smoke buildup owing to burning cork and plastic insulation on the walls, and a maze of freezer compartments.

Winds: A risk factor when suddenly changing direction or gusting during a fire. Wind changes have injured and killed firefighters. A sudden gust of wind can cause a wildfire to flare up and trap a firefighter who is operating in high brush. Wind that suddenly changes direction and blows into a flaming window can drive fire and heat into the path of advancing firefighters who are searching or operating an attack hose line. High winds can cause a treetop (crown) fire to spread over the heads of firefighters operating in the woods. Strong wind affects structural firefighting more frequently than any other weather condition. In addition to stopping the advance of a hose attack team, wind also blows smoke and burning embers toward exposed buildings. A strong wind also speeds up fire and smoke spread inside a common roof space.

X marking of vacant buildings: A strategy to warn firefighters of dangers in a vacant building. A vacant building can be marked near the entrance door by drawing a box 12 inches square, using a fluorescent paint so as to be visible at night. A single diagonal line drawn from one corner of the box to another indicates that there is a firefighter hazard in the vacant building. Two diagonal lines forming an X inside the box indicates that there are multiple hazards in the building and that an exterior defensive firefighting operation should be considered.

Yard hydrant system: Equipment consisting of hydrants, hose, nozzles, and monitor deck guns installed in industrial plants, such as oil depots, lumberyards, and large factories. Yard hydrant systems are not designed for initial use by firefighters. Yard hydrant systems are designed for use by a private fire brigade. Firefighters may take over use of hose lines and monitor nozzles being used by members of a fire brigade on arrival. However, if members of a fire brigade are not present, firefighters should not depend on the yard hydrant system. The arriving firefighters stretch their own hose and pumper and use the public water supply, not the private yard hydrant system.

Zones of danger: Collapse and explosion danger zones. A collapse zone is the distance firefighters should be kept away from a wall that appears in danger of collapse. A collapse zone should be a distance from the wall at least equal to the height of the wall. An explosion danger zone should be established when there is a danger of explosion of high or low explosives or a blasting agent. When there is a danger of blast caused by an explosive mixture, all bystanders and firefighters should withdraw to a distance of 2,000 feet. When there is a danger of a propane tank truck exploding (i.e., a BLEVE), firefighters should withdraw to a distance of 800 feet.

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About the Author

Deputy Chief Vincent Dunn (retired) is a 42-year veteran of the Fire Department of New York (FDNY). He is a recognized authority on firefighting and the recipient of many awards acknowledging his achievements—"Man of the Year" (1990) by the Society of Fire Protection Engineers; the Edward W. Whalen Award (1995) by the New York City, Fire Safety Director's Association; a Lifetime Achievement Award (1999) by *Fire Engineering Magazine*; and the Lifetime Achievement Award (2000) by the New York City Fire Department.

Deputy Chief Dunn is the author of a number of textbooks—*Collapse of Burning Buildings* (Fire Engineering, 1988), *Safety and Survival on the Fireground* (Fire Engineering, 1992), and *Command and Control of Fires and Emergencies* (Fire Engineering, 1999)—and is a contributing editor with *Firehouse Magazine*. He has developed and taught numerous courses for the FDNY, the FBI and the National Fire Academy, and has served as an adjunct professor at Manhattan College. Dunn currently teaches at John Jay College, City University of New York. He has a master's degree in urban studies, a bachelor's degree in sociology and an associate's degree in fire administration from Queens College, City University of New York. Visit Deputy Chief Dunn's web site at www.vincentdunn.com.

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